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## Editorial

### THE RATIONALE OF BURN THERAPY

THE gasoline age quadrupled the incidence of burns. Hi-octane gasoline for airplanes further increased the number of burn cases. With the war we all have become burn conscious, especially those of us in the service. Two-thirds of the Naval casualties at Pearl Harbor were due to burns. On one hospital ship in the South Pacific 360 burns were treated in one year, an average of one a day. At the U. S. Naval Base Hospital in the same area, 154 patients were admitted with an involvement of from 5 to 90 per cent of the body. In war, flash burns, plane crashes, electric accidents and explosions are all important factors. Carelessness, however, is still the prime cause as witnessed by the fact that 50 per cent of the burns seen at this hospital were caused by the 100-octane gasoline used to start brush fires and galley stoves. This figure illustrated well the part negligence played as battle casualties were being admitted daily at that time.

The publication of many articles on burns in which successful results of therapy are attributed to certain local measures has confused the picture. When one travels from one base hospital to another a familiar question is, "What are you using on burns now?" Such questions indicate that in the minds of many the rationale of burn therapy is still not clear.

Successful therapy of burns is not based on local measures. Patients now survive burns of a proportion of the body surface previously considered fatal. In the past, these patients died because reliance was placed on some local therapy of the burned area without appreciation of the underlying pathological processes inaugurated by the burn.

Today, the treatment of a burn can be well outlined. Survival or death may well depend upon: (1) Treatment of shock by the prevention of hemoconcentration, the replacement of tissue fluid lost, and the prevention of further loss; (2) the prevention of secondary infection. In this treatment, local therapy can aid only in the prevention of fluid loss by pressure, and also can minimize the incidence of infection. A simple aseptic petrolatum or vaseline pressure dressing has been found effective and is used in both the Navy and Army Medical Services.

Treatment thus can be summarized: *General*—(1) Intravenous plasma to prevent hemoconcentration and replace fluids already lost; (2) morphine for the relief of pain; and (3) prophylactic tetanus toxoid and gas gangrene serum as well as sulfa drugs and penicillin to reduce possibility of infection. *Local*—(1) Apply dressings under sterile (operating room,

including cap, gown and mask) precautions at first available facility. Do not débride. Where gross contamination requires it, cleanse carefully with mineral oil. (2) Apply sterile vaseline or petrolatum dressings and wrap firmly and evenly. If desired, sulfa powder or penicillin may be applied under the vaseline. Do not disturb the dressings for a minimum of two weeks unless complications require it. (3) Prevent contractures by correct splinting and early grafting.

The local use of petrolatum is but a

return to one of the earliest treatments of a raw area: Its merit lies in the absence of any tissue-injuring chemical and its value is dependent upon the pressure wrapping to prevent fluid loss. When combined with the systemic treatment of the accompanying shock, it is most satisfactory.

No type of dye or ointment, paraffin or plaster of paris cast placed over a burn can replace these fundamental therapeutic principles.

LIEUT. COMDR.

GERALD H. PRATT, M.C., U.S.N.R.



FROM a severe burn there is an early permeability of capillaries leading to the rapid loss of blood serum and such hemoconcentration that the smaller blood vessels may become more or less obstructed by red cells. The plasma largely escapes into the tissues and cavities of the body, but considerable quantities may ooze from the burned surfaces unless the burn is so deep as to produce eschar or carbonization.

From "Principles and Practice of Surgery" by W. Wayne Babcock (Lea & Febiger).

# Original Articles

## A MODIFICATION OF THE PLASMA FIXATION METHOD (Sano) OF SKIN GRAFTING BY THE USE OF BOBBINET AND A MIRROR ATTACHMENT\*

JOHN A. JENNEY, M.D.

NEW YORK, NEW YORK

**B**ECAUSE of difficulties encountered in the application of skin grafts after the method of Dr. Sano, we devised methods which have helped eliminate many of them. These involve the use of bobbinet on the drum of the Padgett dermatome and a mirror which is attached to the cutting arm.

Among these difficulties were removing of the graft from the dermatome; contraction of the graft and the sticking of its cemented surface to adjacent surfaces; holding the graft on the recipient area long enough for it to stick, this difficulty mounting in proportion to the irregularity of the surface to be grafted; the necessity of cutting a much larger piece of skin than the area to be covered, because contracted skin can be worked better than taut skin; mutilation of thin grafts when separating them from the dermatome; and interference of vision of the operator produced by the drum during the manipulation of cutting the graft, thereby making any changes in the thickness of the graft or its broad contours difficult.

The method we have been using with success is as follows: A large piece of fine cotton bobbinet is thoroughly washed in soap and water, stretched with pins to its original dimensions and firmly pressed to flatten the threads. Smaller pieces are then

cut from the large piece, each one about one inch larger in all directions than the area of the drum of the Padgett dermatome. The drum of the Padgett dermatome is painted with rubber cement and allowed to dry for a few minutes. A piece of bobbinet is then rolled on the drum. (Fig. 1.) This should be large enough to overlap the ends and sides of the drum. Another coat of rubber cement is then applied which should be sufficient to saturate the bobbinet thoroughly. The ends and sides are pasted down and the drum is ready for heat sterilization. Drums have been autoclaved for forty minutes at 240 degrees of temperature and 20 pounds of pressure without destroying their effectiveness. Adhesive qualities of the sterilized drums are tested with the surgeon's glove; if it is a little dry the drum is repainted with a thin solution of the particular cement in use and its solvent. If sterilized in a steam sterilizer the drum should be placed above the bubbling water or some of the rubber will wash off.

A pattern is then made of the recipient area with a piece of cloth or cellophane, is marked and transferred to the area from which the graft is to be taken. The donor site is outlined with dye exactly after the pattern if the graft is to cover an area from which granulations were removed and a

\* This method was presented to the Clinical Society of the N.Y. Polyclinic Medical School and Hospital on April 3, 1944. A Kodachrome motion picture of an operation was shown using this method and patients were introduced on whom this method of skin grafting was used. It was presented also to the Staff Meeting of the Jersey City Medical Center on April 6, 1944. A Kodachrome motion picture of an operation using this method was shown, patients were introduced on whom this method of skin grafting was used and the mirror was demonstrated.

little smaller if the graft is to cover an area from which scar tissue was removed. Cross lines are made across the skin to be re-

wise the gloves must be removed because the sheet will stick to the gloves. This does not interfere with sterility of the

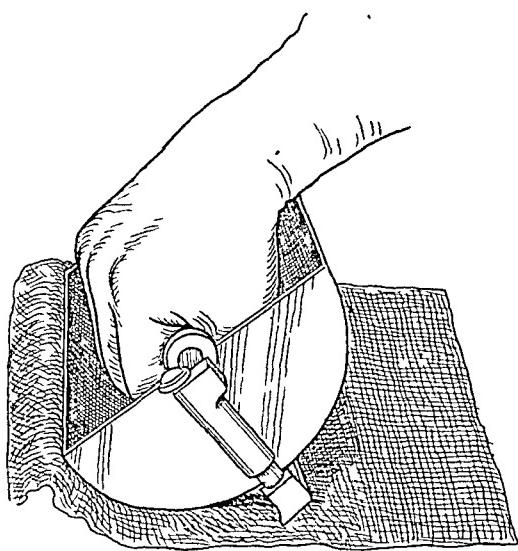


FIG. 1. Method of applying bobbinet to the drum. The convex surface, sides, and inner surfaces of the ends are painted with rubber cement. The bobbinet is then rolled on the convex surface and pasted to the sides and inner surfaces of the ends.

moved following the marks previously made on the pattern. The skin is then superficially incised with a scalpel along the line of the borders of the graft. This causes a slight amount of gapping and permits accurate cutting of a pattern graft. The area within the incised line is cleansed with ether and painted with rubber cement; the area outside of the incised line is powdered with talcum, sulfadiazine, etc., to prevent the rubber on the dermatome from sticking to the skin. The skin around the recipient area is painted with rubber cement.

The knife blade is then set in the usual manner; the surface of the bobbinet is zero. After attaching the mirror the instrument is ready for use. The drum is pressed on the cemented skin and the graft is cut in the usual manner. (Fig. 2.) After cutting, the ends of the bobbinet are loosened and clamps are applied. Powder is then applied to the rubberized surface next to the drum if no further use of this surface is contemplated (patching); other-

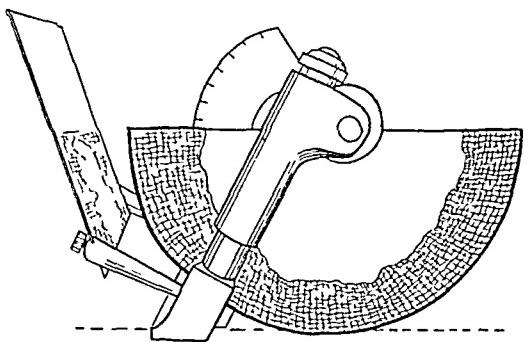


FIG. 2. Prepared drum with mirror. In this case the mirror posts are attached to the knife-holding portion.

graft because the hands do not touch it. By gentle traction the fabric with adherent skin is pulled off the drum.

Graft and recipient areas are treated according to the plasma fixation technic of Sano. If Tyrode solution is not available, we use normal saline in its place. For con-

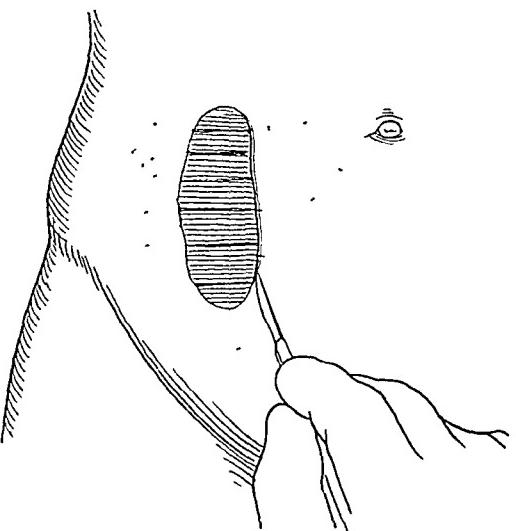


FIG. 3. Lightly incising through the outline of the area to be grafted by means of scalpel.

venience at times we have used a prepared thrombin preparation with equally good results.

When applying the graft to the recipient area the assistant holds one end of the rubberized fabric up and the operator

### PLATE 1

Contracted scar of the lower eyelid, nose and cheek. A, injection of novocatin into the scarred area. No harmful effects are produced by local anesthesia in skin grafting. B, reflection of bobbinet and graft in the mirror during the process of cutting. Mirror posts are attached to sections of the blade clip. C, graft and bobbinet held above the recipient area. D, graft pasted to the recipient area. Stitches have been placed along the lid margin through the bobbinet. E, unrefined final result.



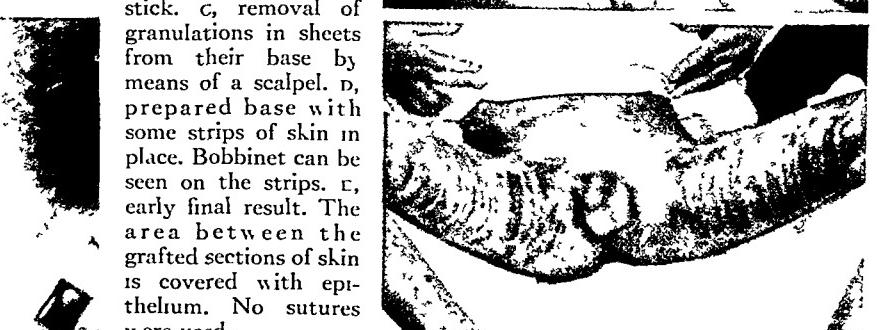
PLATE 1



PLATE 2

### PLATE 2

Third degree burns of the abdomen, genitalia and thighs. A, extent of the granulating area. B, cauterization of a section of granulations with a silver nitrate stick. C, removal of granulations in sheets from their base by means of a scalpel. D, prepared base with some strips of skin in place. Bobbinet can be seen on the strips. E, early final result. The area between the grafted sections of skin is covered with epithelium. No sutures were used.



### PLATE 3

Avulsion of the superficial tissues of the thigh. The muscles of the thigh were exposed. A, inner view of the thigh and extent of the granulations. B, outer view of the thigh and extent of the granulations. The successful graft over the knee is seen through bobbinet which is almost invisible because mineral oil has been applied over it. A small section of overlap with sutures is seen along the lower border. The white area above the graft is the remnant of a graft taken from the mother; the portion of the mother's skin over the knee was removed for autogenous grafting. C, graft applied to the lateral aspect of the thigh. Mineral oil has not been applied over the bobbinet so it appears very white. D and E, unrefined final result.

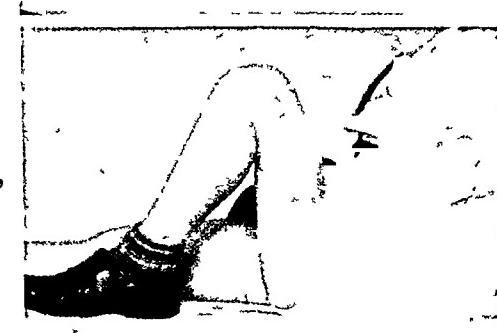
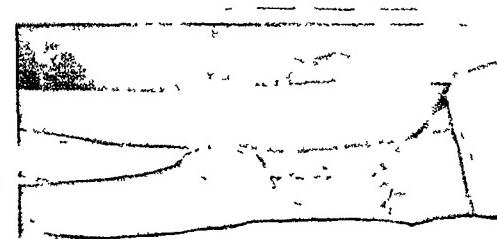
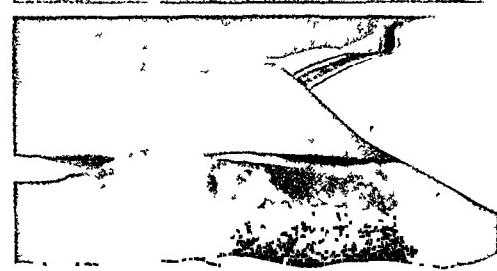


PLATE 3



### PLATE 4

Third degree burns of the hand. A and B, extent of the granulating area. C, the graft on the fingers seen through the bobbinet. D, E and F, hand immediately after removal of the bobbinet from the fingers (second stage). No sutures were used.

PLATE 4

guides the graft to its ultimate location. When this is accurately placed, the operator presses the far end down and the assistant presses the fabric on the rubberized skin around the recipient area where it adheres. The assistant then holds up the fabric and the operator, using both hands, rolls it in place, sighting along the undersurface of the graft. As he rolls it down he presses the rubberized fabric to the prepared skin. In this manner accurate approximation of the graft to the recipient area is insured.

If the recipient area is uneven, as in a graft of the forehead, eyelids, nose and cheek, or uneven and depressed as in the repair of a Dupuytrens contracture, the assistant follows the operator down, applying damp cotton wadding on the rubberized fabric to hold the graft to the irregularities and eliminate air pockets. In such cases the skin edges are inspected without removing the wadding from the broad surface of the graft, sutures are placed if needed or fabric adjustments made and a pressure bandage is applied. If the edges need adjustment, the fabric is pulled off the skin in the area, adjustments are made and the fabric is replaced.

Dr. J. Eastman Sheehan and Dr. Lawrence Gatewood have aided the author in a study of cases in which this method was used. We have concluded that pressure bandages over the graft and immobilization of the part are essential for the best results. This insures perfect apposition of the graft to the recipient area and also prevents air pockets and oozing. Good results have been obtained on even surfaces with no dressings at all over the fabric, but we have noted that bleb formation is more common whenever pressure bandages are not used. In general the type of dressing used and the time of the first dressing is determined by the character of the base and the site of the graft. If the base is smooth, and satisfactory bandaging is difficult, we immobilize the part in traction and do not use any bandages over the bobbinet. An example of this would

be a large sheet of graft over the inner aspect of the thigh. The danger of wrinkling with the loss of a large part of the graft

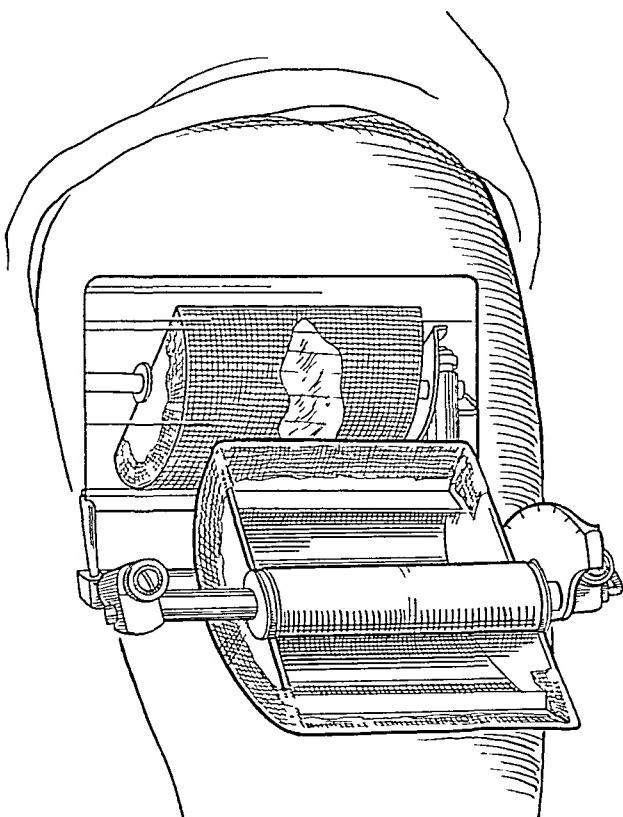


FIG. 4. Reflection of the bobbinet and graft in the mirror.

is great in this region so we immobilize the part in a Thomas splint with traction, and no bandages are placed over the bobbinet. Otherwise we usually use strip grafts in this region with pressure bandages. In the latter case wrinkling of one strip will not affect other strips. If pressure bandages are applied, they are changed in five days and replaced for a few more days if the case warrants it. If there is much overlap of the edges, the rubberized fabric is removed from the overlapped sections and the skin is allowed to dry up.

Dressings above the bobbinet and the bobbinet itself are easily removed. In order to leave the bobbinet in place the top layers of the dressing are picked off and the layers next to the bobbinet are saturated with ether or the particular solvent used for the rubber cement. The bandages can then be picked off the

rubberized bobbinet. If the bobbinet is to be removed, the solvent is poured over it and it is picked off without adhering to the graft.

Granulations are cauterized freely with silver nitrate sticks and removed in a sheet from their base by stripping them off with a scalpel. This not only insures a sterile

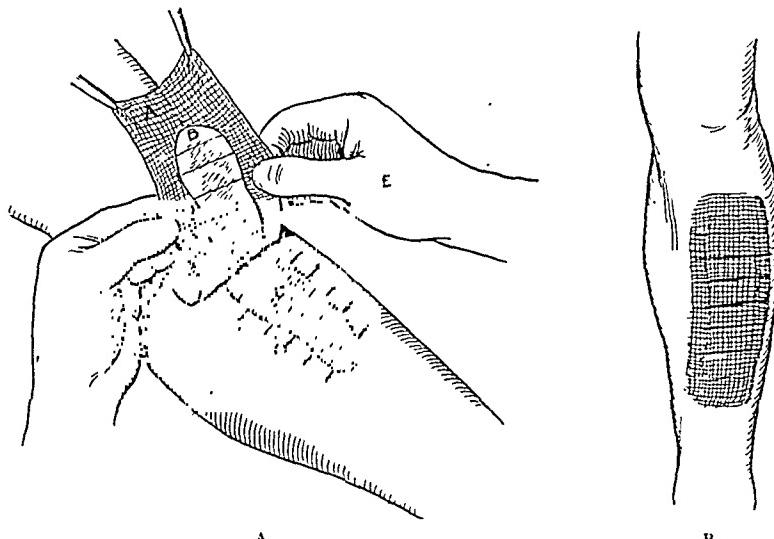


FIG. 5. A, method of applying the graft. A, rubberized bobbinet; B, graft adhering to the rubberized bobbinet; C, recipient area; D, rubberized skin around the recipient area; E, position of the hands when applying the graft to the recipient area. B, graft in place. The rubberized bobbinet is pasted to the rubberized skin around the recipient area.

At times it is advisable to continue immobilization for a longer period and also protect the part for a longer time as in treating children. In these cases the bandages are re-applied. As the fabric is separated from the graft with the bandages practically untouched, the bandages are in the form of a mold of the part. When replaced they fit the area perfectly.

When covering large granulating areas we use strip grafts. The sheet of fabric and skin is held at each end with clamps and narrow strips are cut. These are then laid across the prepared base and pasted to the skin around the area. Excess pieces are cut off (overlap), layed end to end, and pasted together with strips of prepared bobbinet to make another strip. In this way no skin is lost. The skin around the recipient area is painted with rubber cement.

When dealing with irregular areas, the sheet of skin and fabric is cut in any desired pattern and pasted on as described when strip grafting.

base but also removes excess tissue which is not needed for skin growth and will only result in scar tissue later. Wet saline packs are applied to the denuded area and oozing stops in a few minutes.

Drainage slits are never made. Grafts are applied only on a perfectly dry base and we expect growth in every part of the graft, therefore making slits over possible sites of trouble would be a blind procedure.

*Choice of Fabric.* We tried various fabrics including different weaves of women's stockings but found that fine cotton bobbinet was the best material available to us. It has a very fine thread, stretches in all directions and will follow any contour very easily. A fine silk or possibly a fine nylon mesh would be better. Fabrics made of rayon are unsuitable because rayon disintegrates in the high temperatures of the autoclave if left in for the usual period of sterilization.

*Adhesive.* Only different brands of non-vulcanizing rubber cement have been used and all with success. However, the dis-

advantage with some brands is that they are highly pigmented, the edges of the wound cannot be easily seen and adjustments are difficult to make. Any of the light colored cements are satisfactory.

*Mirror.* The mirrors are cut from large metal mirrors such as are used by photographers. They measure about 7 inches by  $3\frac{1}{2}$  inches and are supported by mirror posts of which we have made two types: The first type is screwed into the center of the flat surface of the knife holding portion of the dermatome above the blade rest and projects at right angles to it. The second type of posts is attached to the centers of two one-inch sections which are cut off the knife clip, and project outward at an angle of 10 degrees to the skin surface. The first type of posts is about  $1\frac{3}{4}$  inches long, the second type is about  $1\frac{1}{4}$  inches long. Slots are cut in the mirror ends of the posts so that the mirror is set at about 45 degrees to the skin surface. The mirrors are held in place with thumb screws which are placed in the ends of the mirror posts. Posts are elevated to prevent dragging on the cut surface of the skin.

#### ADVANTAGES OF THE BOBBINET

1. The graft adheres to the rubberized bobbinet because it presents a comparatively rough surface.

2. The graft can be easily handled and can be easily placed on the recipient area. Thin grafts are not mutilated.

3. The graft can be cut into any shape to cover accurately the areas to be grafted. The pieces are pasted on.

4. The graft can be easily applied to areas which are surrounded with scar tissue which would make suturing impossible.

5. The graft is placed on the recipient area in the same condition it was removed from the donor area. Contraction of the graft can be easily overcome by merely stretching the rubberized fabric.

6. Widely expanded raw areas resulting from excision of scars in normal skin can

be made smaller by "tucking in" the skin as the graft is pasted on.

7. The graft can be made to conform to any elevation or depression; it can be moulded over forms to line cavities as in buccal inlays or line the ends of tubes when this is necessary.

8. Only a minimum of skin is lost because the amount of skin excised is patterned after the area to be covered.

9. Free sheets of rubberized bobbinet can be made prior to operation and used for patching.

#### ADVANTAGES OF THE MIRROR

1. The operator is in a comfortable position.

2. Reflected light from the mirror gives complete illumination to the graft.

3. The graft is in full view of the operator at all times.

4. The operator can see exactly the operation of the knife at the commencement of the excision.

5. The drum during its manipulation over the surface does not interfere with the operator's vision and adjustments for thicker or thinner cuts can be made.

6. The proper cutting angle is fixed if the operator holds his head in a steady position; if the cutting edge is seen, the angle is correct; if it moves up or down, it is incorrect.

7. Lateral motion is possible while viewing the operation through the mirror. If the blade is cutting into adjacent tissues, this can be seen immediately and can be corrected by lateral tilting of the drum of the dermatome.

8. Variations in the thickness of the graft can be made by viewing the cut in the mirror. Cross lines made on the skin prior to cutting can be seen through the split skin. Tapping the thickness gauge at predetermined points allows thick and thin sections to be cut on the same piece of skin.

9. By using the mirror, the operator can stand far enough away to get a comprehensive view of the graft while cutting.

# ADMINISTRATION OF INTRAVENOUS FLUIDS TO SURGICAL PATIENTS\*

PAUL F. FOX, M.D.

Attending Surgeon, St. Anne's Hospital  
CHICAGO, ILLINOIS

INTRAVENOUS fluids are used frequently in surgical practice. The intravenous route has, on the basis of merit, almost entirely replaced the other parenteral methods of administering fluids except in unusual situations.

It seems worth-while to discuss some of the commonly used fluids that are given by vein to surgical patients, and emphasize certain principles governing their administration. An attempt will be made to embody in one article certain facts which may be of some value as a guide to intravenous therapy. Less commonly used fluids are also mentioned because they will undoubtedly be used to a greater extent in the future.

It is well to bear in mind that a large number of surgical patients require intravenous fluids for only a few days. These patients quickly regain their normal physiologic status after they begin to eat and drink. However, seriously ill patients who for one reason or another cannot take food or water by mouth offer a real problem to the surgeon as they must be maintained parenterally (usually intravenously) for a variable number of days. It is these patients who require an understanding on the part of the surgeon of the principles of proper fluid therapy, and at times the outcome in a severe surgical illness depends upon the efficacy of this therapy.

The substances themselves to be described from the standpoint of intravenous administration are water, salt, dextrose, blood, plasma, amino acids, gelatin, pectin, and miscellaneous fluids.

## WATER

Coller and Maddock<sup>1-5</sup> have made intensive and valuable studies of the water requirements in surgical patients. They have estimated the water loss in sick surgical patients and have found that 1,000 cc. to 1,500 cc. was the average daily amount required for water of vaporization. This water of vaporization is lost by way of skin and lungs and is part of the heat dissipating mechanism of the body. Under unusual conditions such as high fever, excessive sweating, hot humid weather and hyperthyroidism, this loss may be increased to 2,000 cc. or more each day. After the heat dissipating mechanism (or water for vaporization) is supplied the remainder of the available water is utilized for urine output. A satisfactory urine output depends upon several factors. It has been demonstrated<sup>6</sup> that approximately 500 cc. of urine is the minimum daily amount required to excrete 35 Gm. of waste material (an average daily amount). To do this the normal kidneys must function at a maximum concentrating power (shown by a high specific gravity). With the volume of urine less than 500 cc., retention of waste material, manifested in the blood by an increased non-protein nitrogen, will occur. If the kidneys are diseased and cannot concentrate normally, more water is needed. Thus with a concentrating ability that is down to 1.010 about 1,500 cc. of urine is needed to get rid of the 35 Gm. of waste material.

For the average surgical patient 1,000 cc. is a good daily urine volume with a specific gravity in the middle range. For seriously

\* From the Department of Surgery, St. Anne's Hospital.

ill patients, perhaps a larger output is desirable, although there is some objection to a large fluid intake especially in the thyrotoxic patient.<sup>7</sup>

Certain recommendations have been made by Coller and Maddock which are adequate in most cases, but can be varied to suit individual requirements. For uncomplicated cases 2,000 cc. to 2,500 cc. of water daily (1,000 cc. to be water for urine) is sufficient. For complicated cases 3,000 cc. to 3,500 cc. daily (1,000 to 1,500 cc. to be water for urine) will be required.

In our own practice we have found the urinary output to be a satisfactory index of water balance in most instances. In general the plan suggested by Coller and Maddock has been followed. It should be noted, however, that old people who are poor surgical risks do not handle large amounts of intravenous fluids well. This is because the fluid lost by vaporization is so variable that the urine loss is not always a safe guide. In these doubtful cases Wangensteen<sup>8</sup> has used the bedside weighing plan. If a patient has a low urinary output, daily weighing will determine whether administered water has been retained in the body or lost through vaporization.

Drew<sup>9</sup> and others suggest measuring the state of hydration by using the hematocrit determination of venous blood, the specific gravity of blood, the specific gravity of plasma, and the protein concentration of the plasma as calculated from the plasma specific gravity. The frequent performance of these tests would probably be the safest and best index of satisfactory water balance.

#### SALT

The average daily salt requirement is 5 to 10 Gm.<sup>10</sup> If the intake is greater than the requirement, most of the excess is excreted in the urine. In health this is easily done but in a sick, surgical patient an excessive intake of salt may produce edema<sup>5</sup> as the kidneys cannot excrete the excess as they do in health. In combination

with hypoproteinemia, excessive salt produces edema even more quickly. It is inadvisable to give more than one liter of normal saline solution daily (8.5 Gm. salt) to a patient unless there are abnormal salt losses.

Abnormal salt losses occur through excessive perspiration, continuous gastroduodenal suction, vomiting, diarrhea, intestinal or biliary fistulas, or in any other condition in which bodily fluids are lost. These losses must be measured whenever possible and as they contain a fairly consistent amount of salt per liter, correction must be made in the daily calculation for fluid requirement.<sup>5</sup> As none of these fluids (which are abnormally lost) contain more than 5 or 6 Gm. of salt per liter, they may be satisfactorily replaced with normal saline solution, volume for volume. Thus if a patient loses 1,000 cc. of fluid through gastroduodenal suction daily, the replacement necessary would be 1,000 cc. of normal saline solution. This would be in addition to the liter given to satisfy body requirements, making 2,000 cc. of saline necessary. If still more fluid is required (as estimated according to the requirements described under water), it would be supplied by dextrose in distilled water or by amino acid solution.

The plasma chloride level is normally 560 mg. per 100 cc. If the chlorides are depleted to 450 mg., symptoms usually appear. These are noted as depression, fatigue, nausea, and, if the chloride level continues to drop, stupor may occur. To correct the salt deficiency as estimated by the plasma chloride level Bartlett<sup>10</sup> recommended giving 0.5 Gm. of salt per kg. of body weight for each 100 mg. of plasma chloride loss.

Thus if a patient weighed 50 kg. and the plasma chlorides were found to be 460 mg., the amount of salt would be calculated as 0.5 Gm. (salt)  $\times$  50 (kg.)  $\times$  1 = 25 Gm. salt needed to bring the level to 560 mg.

Daily plasma chloride determinations may be made on patients who have low

chlorides, or the urinary chloride may be estimated. If there is more than 1 Gm. of salt in the daily urine, great salt loss will not occur. If the plasma chlorides cannot be raised to normal by Bartlett's formula no more should be given as edema will occur.

When the patient recovers sufficiently to begin eating, the chlorides usually return quickly to normal. In the presence of hypoproteinemia, salt administration according to the formula given may produce edema. In these cases the plasma chloride levels may be normal or below normal. The plasma chloride level is, therefore, no measure of salt retention but should be a useful guide in salt loss. Retention of salt from excessive administration will cause hydremia rather than hyperchloremia.

The indications for Ringer's solution are approximately the same as those for normal saline solution. Ringer's solution contains less sodium chloride (0.6 per cent) and has small amounts of potassium chloride (0.004 per cent), calcium chloride (0.002 per cent) and magnesium chloride (0.002 per cent). It has been stated to be of value when fixed bases are lost.<sup>18</sup>

Ringer's lactate solution (Hartman's) is essentially the same solution as Ringer's, with the addition of sodium lactate (0.3 per cent), and it is used in similar situations.

#### GLUCOSE

Glucose solutions are valuable in the prevention of ketosis, in protecting the liver, and supplying water and food. A 5 per cent solution in distilled water is isotonic, a 10 per cent solution is perhaps best given to patients with liver damage, hyperthyroidism, or malnutrition. If a given patient requires 3,000 cc. of intravenous fluid a day and there have been no abnormal salt losses, 1,000 cc. would be given as normal saline solution and the remainder as 5 per cent glucose in distilled water or perhaps 5 per cent glucose with amino acid solution.

Winslow<sup>11</sup> showed that 98 per cent of

5 per cent glucose solution in distilled water was retained when 3,000 cc. was administered daily at the rate of 300 to 500 cc. per hour. The same amount of 10 per cent glucose given at the same rate was 95 per cent retained.

#### BLOOD

The value of blood transfusion, especially to correct loss of blood, has been well established. In serious injuries with marked blood loss, and in operative procedures in which blood loss is expected to be extensive, transfusions of whole blood are demanded. The administration of whole blood before and during serious operative procedures is now a common practice and certainly has been of great benefit to many patients both in the prevention of post-operative shock and in aiding convalescence. Shock due to blood loss should be treated by blood transfusion, if blood is available. If not available, plasma is an effective substitute. Shock due to burns, or to an injury not associated with blood loss, is perhaps better treated with plasma, as the colloidal osmotic pressure of plasma is twice that of an equal volume of whole blood. Probably the best guide as to the need for whole blood is the extent of the patient's anemia.

The indirect method is the one most frequently used at the present time. Its advantages are quite obvious especially since citrated blood may be stored for a few days before use. Sodium citrate has been shown to produce toxic reactions if given rapidly in large amounts.<sup>12</sup> The usual amount used as an anti-coagulant is 10 cc. of 2 to 4 per cent sodium citrate solution to 100 cc. of blood. Heparin may be used as an anti-coagulant if desired. Glucose may be added to the citrated blood allowing it to be stored for longer periods as it decreases the tendency toward hemolysis.

In the blood bank maintained at our hospital whole blood is stored for a maximum period of seven days, after which it is centrifuged to obtain plasma. Sodium

citrate (4 per cent) is used as the anti-coagulant. The blood is stored at approximately 4°c. It is checked for hemolysis before use and is usually given to the patient directly after removal from the refrigerator.

Reactions from blood transfusion are at times a source of grave concern. They are usually due to pyrogenic substances in the apparatus used. Meticulous cleansing of the tubing, connections, and needles immediately after use, preferably by the same individual is helpful in avoiding these pyrogenic reactions. Routine typing, careful cross matching and Wassermann or Kahn tests are, of course, essential prerequisites to any transfusion of whole blood.

Some of the previously unexplained reactions have been found to be due to the existence of the Rh factor.<sup>13,14,15</sup> These reactions are of interest to surgeons when a patient requires repeated transfusions. The Rh factor is present in the blood of 85 per cent of all people. These are Rh positive. The 15 per cent who have no Rh factor are called Rh negative. If the recipient is Rh negative and is given repeated transfusions of Rh positive blood, he will develop anti-Rh agglutinins in his blood. After several transfusions, a reaction may occur. It is for this reason that the military services determine the Rh factor of patients requiring repeated transfusions, as these reactions may be severe and serious.

#### PLASMA

Plasma is ordinarily prepared by removing the cellular element from citrated whole blood. It may also be prepared from blood in which heparin has been used as the anti-coagulant. Serum is quite similar to plasma except that it is taken from whole blood which has been allowed to clot. After the clear liquid has separated from the clot it is aspirated. Serum thus contains no fibrinogen.

The value of plasma is unquestioned in many surgical conditions. Severe burns,

shock without hemorrhage, shock with hemorrhage (when whole blood is not available), hypoproteinemia (particularly acute) are all instances in which plasma is indicated. The hemoconcentration offers a good index as to the amount of plasma needed in burns and shock without hemorrhage. The elevation of lowered plasma protein levels is somewhat difficult to accomplish as Scudder<sup>16</sup> and Mahoney<sup>17</sup> have pointed out. Large amounts of plasma must be given. Perhaps some of this protein is immediately taken up by the tissues which need it and thus the plasma protein level does not rise until the tissue needs (due to depleted tissue protein) are satisfied. However, with intravenous plasma, the protein level can be maintained above the so-called "critical point" (5.2 Gm.) until the patient can take food.

The advantages of plasma are such that it is a substance of great usefulness. It may be dried or frozen and stored safely for a long time. Pooled plasma may be used as a source of supply. Concentrated plasma (four to six times) may be used for the treatment of cerebral edema.<sup>18</sup> Reactions are few and are less common after the use of pooled plasma.

The disadvantages that may be attributed to plasma are that one donor is necessary to obtain 250 cc., that very large amounts are necessary in certain conditions, and that it is expensive.

Elman and Lischer<sup>20</sup> studied experimentally the use of amino acids, serum, and plasma in the therapy of fatal shock due to repeated hemorrhage in unanesthetized dogs. Replacement of blood loss by the various substances showed differences in the survival time. It was unchanged with glucose in saline, increased to 4.2 hours with amino acids and to 4.5 and 4.6 hours, respectively, with citrated plasma and serum. With heparinized plasma, the survival time was six hours. Fall in blood pressure was greater with citrated plasma and serum than with heparinized plasma. This seems to imply that heparinized plasma is of very definite

value in the treatment of shock due to hemorrhage.

#### AMINO ACIDS

The intravenous use of amino acids in the prophylaxis and treatment of hypoproteinemia in surgical patients is a procedure of great value. For many years the water, salt, and glucose requirements of patients were carefully watched but only recently has the protein requirement and the occurrence of hypoproteinemia aroused special interest.

The excellent contributions of Elman<sup>20-27</sup> on this subject, particularly with reference to the surgical patient, are deserving of thorough study. Other contributors<sup>28-31</sup> have made valuable additions, and their work, together with that of Elman, is the basis for most of the knowledge which may be applied to the problem of hypoproteinemia in surgical practice.

The amino acid solution is prepared from the digestion of casein by pork pancreas. It is carefully sterilized according to definite specifications and is given commonly as a 5 per cent solution (of amino acids with 5 per cent dextrose solution although it may be administered in other concentrations. This preparation may be obtained in liter flasks ready for use, each liter containing 500 cc. of 5 per cent solution of amino acids (amigen) and 500 cc. of 5 per cent dextrose solution. All the essential amino acids are contained in this solution, as determined by growth tests in animals. The preparation is much less expensive than plasma and for correcting hypoproteinemia is an efficient substitute. Reactions to the intravenous administration are very few and not serious. Flushing, a feeling of warmth and nausea, are the usual reactions and disappear when the rate of flow is reduced. Some instances of phlebitis have been reported after repeated use. The fact that the protein is in the form of amino acid is important as this is the form in which normally digested protein enters the blood stream. The liver is probably spared in

this way because there is no necessity of breaking down proteins to amino acids. It should be pointed out, however, that about one-third of the protein in the solution is in the form of dipeptides. This is of no practical significance.

The necessary amount may be varied to suit individual needs. Usually 1 Gm. of protein per kg. of body weight is the basis for calculation of nitrogen requirement. Amino acid solution will maintain nitrogen balance, will correct hypoproteinemia and will produce elevation of the albumin fraction if given in sufficient quantity. Most fasting patients excrete from 4 to 5 Gm. nitrogen a day when sufficient glucose is given to meet caloric needs. Some excrete much more which is supposed to indicate a toxic destruction of body protein. This loss may be prevented by furnishing extrinsic protein in the form of amino acids. Adequate amounts of glucose must also be given with amino acids to furnish energy, otherwise the proteins will be drawn upon for this purpose and will not be available for the correction of the tissue protein loss and the hypoproteinemia.

The rate of administration varies with the individual patient. Usually the 5 per cent solution may be given at the rate of 300 to 500 cc. per hour. If warmth or flushing occurs, the rate may be easily decreased.

The fact that amino acid solution can produce elevation of the plasma albumin is of tremendous significance. The albumin fraction is the one most affected in surgical conditions.<sup>27</sup> This fraction contributes 85 per cent of the colloidal osmotic pressure of the plasma. It is also present in twice the concentration of globulin in normal plasma. For every Gm. of plasma albumin lost or gained approximately 30 Gm. of tissue protein is lost or gained. Thus, if amino acid therapy makes possible the control of this factor the many complications due to hypoproteinemia should be, at least, partially preventable.

The clinical manifestations of hypo-proteinemia as given by Elman<sup>27</sup> are serious and important. Surgical shock, suppression of urine, hemoconcentration, abdominal distention, edema, ascites, and faulty wound healing may all be due to this condition. In view of these clinical evidences the importance of an adequate protein intake needs hardly to be re-emphasized.

Our personal experience with amino acid solution (amigen) has been limited, but a satisfactory and sometimes striking clinical improvement has been noted after its administration to seriously ill patients. Plasma protein levels were maintained at or near the normal values.

Severe hepatic insufficiency probably contraindicates the use of amino acid solution, although it has been used where liver damage was evident with no untoward effect. Otherwise there are apparently no contraindications.

#### GELATIN

Because of the difficulties encountered in obtaining and processing blood and plasma, as well as the expense, search is constantly in progress for an effective blood or blood plasma substitute.

Gelatin has been investigated from this standpoint. Hogan<sup>32</sup> was the first to use it intravenously in 1915 but since then, interest in gelatin as a blood substitute was lacking until fairly recently. Parkins<sup>33</sup> and others studied its value as a plasma substitute in experimental hemorrhage and burn shock in dogs. As the composition of gelatin solution varies with the source and method of preparation, it is necessary to describe each solution used. Parkins used a 6 per cent solution in 0.85 per cent saline. Repeated infusions caused no toxic reactions and superiority over normal saline infusions in the management of experimental hemorrhage was definite. It caused more marked hemodilution than plasma with uniform volume replacement. Their experiments indicated that gelatin was a suitable substitute for plasma in experi-

mental hemorrhage. In experimental burns gelatin compensated for loss of plasma and correction of hemoconcentration as well as plasma did. The survival time was greater, however, in the animals treated with plasma. The conclusion was reached that if a factor can be identified in plasma which accounts for its ability to maintain blood pressure in the severely burned animal during the secondary phase of so-called acute toxemia, the addition of this factor to gelatin would probably result in a more adequate plasma substitute for burns.

Brunschwig, Corbin and Johnston<sup>34</sup> investigated gelatin from the standpoint of nutritive value, tolerance by man and ability of the body to metabolize it. They state that gelatin is an incomplete protein and that all essential amino acids are not present. It may serve as a source of nitrogen but is not adequate. Their patients tolerated intravenous infusions well, and at least part of the gelatin was catabolized. Gelatins vary widely in character depending upon the source and methods of manufacture.

#### PECTIN

Another material which has been considered as a possible substitute for blood or plasma is pectin solution. Hartman and others<sup>35,37</sup> have shown that it is non-antigenic and non-toxic. A 0.5 per cent solution has about the same viscosity and osmotic pressure as whole blood. It is easily obtainable, (from citrus fruits) and readily prepared. It is sterilized by heat, should be neutralized and have electrolytes added. It should also be tested for viscosity, hemolysis of red cells, sedimentation of red cells and precipitation of fibrin before being used clinically. Temporary retention in the blood and liver may occur but excretion of unchanged material in the urine is rapid.

Pectin solutions produce a marked and sustained rise in the plasma volume of normal individuals.<sup>36</sup> The degree of increase corresponds to the amount injected and

persists from four to twenty-four hours after the infusion is completed. Saline solutions produce a much less striking rise. Hartman<sup>37</sup> states that the label on the flask containing the pectin solution should indicate the physical characteristics and the method of preparation and sterilization. Precipitation of prepared pectin solutions to form a fine light powder which may be readily redissolved in sterile water, isotonic saline, or dextrose solution has been accomplished. Increased sedimentation rate occurred in patients given pectin intravenously. Coagulation time remained normal and bleeding time was shortened. Results in 125 clinical cases<sup>37</sup> showed sixty-eight good results, twenty-seven fair and five poor results. Clinical improvement and maintenance of blood pressure were used as criteria.

Good pectin solutions are clear, have a viscosity of 2 to 4 at 38°C., and an osmotic pressure of 45 to 70 mm. Hg., depending upon whether 0.75 or 1.5 per cent solution is used. The molecular weight varies from 60,000 to 75,000. The solutions are prepared by multiple filtration and heating for from fifteen to eighteen hours.

Meyer<sup>38</sup> and others used pectin in treating sixty patients in shock. They demonstrated its effectiveness and observed marked hemodilution after its use. No undesirable side effects occurred, except increased sedimentation rate and this was not considered troublesome.

#### MISCELLANEOUS SUBSTANCES

Certain other fluids have from time to time been tried and found impractical because of limited availability or uncertain properties.<sup>18</sup>

These are bovine plasma, bovine albumin, isinglass, crystallin hemoglobin, human ascitic fluid, cadaver blood and placental blood.

Gum acacia solutions, which were formerly used a good deal, are objectionable because of frequent reactions, distortion of the blood count for long periods, deposi-

tion of the acacia in the liver, and incompatibility with citrated blood.

#### COMMENT

This article embraces a wide subject matter. Bringing together in one article a description of the various commonly used intravenous fluids may prove of value to the surgeon in his daily work.

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# VASELINE GAUZE CONTACT FIXATION OF SPLIT THICKNESS (PADGETT) SKIN GRAFTS\*

WILLIAM M. ROBERTS, M.D.

AND

HOWARD J. SCHAUER, M.D.

Surgeon-in Chief, North Carolina Orthopedic Hospital

Resident Surgeon, North Carolina Orthopedic Hospital

GASTONIA, N. C.

THE purpose of this paper is to discuss the use of split thickness skin grafts obtained with the Padgett dermatome for covering large granulating areas secondary to severe burns and the use of a method of application of such grafts which has proved successful in our hands. We refer to this method as vaseline gauze contact fixation of split thickness (Padgett) skin grafts. This has proved to be the simplest method which we have used in covering large areas of granulating tissue and in cutting such grafts to a fixed pattern. It will further be our purpose to discourage the use of pinch grafts in covering the large granulating areas.

During the past twenty-two years many types of skin grafts have been used at the North Carolina Orthopedic Hospital to cover defects in the dermis due to such conditions as congenital defects, mechanical and chemical trauma and burns. More than five hundred patients have been grafted during the past two or more decades, many of the patients requiring numerous skin graft operations. Previous to the advent of the Padgett dermatome,<sup>1</sup> the Gillis tube, the pedicle graft, the pinch graft, and the full thickness skin graft were used almost with equal frequency. The results were good functionally but too often the cosmetic end result was not desirable. We found the poorest cosmetic results were obtained by use of the pinch graft, as the healed grafted area contracted sharply and had a pebbled appearance. (Fig. 1.) Of course, concomitant with the pebbled recipient area always was found the spotted, scarred donor region. The better cosmetic results were obtained by

means of the pedicle and free skin grafts as well as with the Gillis tube. For the rebuilding of destroyed skin organs, the pedicle skin flap and Gillis tube grafts are undoubtedly far superior to any other type of graft. The tube graft supplies required thickness for filling concavities, and for rebuilding a part which requires two soft, pliable, epithelial surfaces and some thickness it has no equal. However, when large granulating areas or large open wounds with sufficient physiologic base are to be covered, we believe the tube graft is not indicated, as it results in too bulky a graft when only a thin dermal covering is necessary.

With the introduction of the Padgett dermatome it was found that a free skin graft of uniform thickness could easily be obtained, and large areas could be grafted in a short time. However, the problem of fixation of the graft to the donor area remained as a tedious job, requiring the suturing of the graft either to the healthy skin surrounding the recipient area, or suture of the graft to a carrying vehicle such as *gutta percha* or cellophane. Such suturing required a good bit of time especially if the graft was large or if the blanket graft of McPheeters and Nelson<sup>2</sup> was used to cover large areas. To overcome this problem we began using flamed adhesive strips of tape to hold the graft in place at the recipient area; the grafts and adhesive straps were then covered with vaseline gauze and pressure dressings. However, even this method, though more rapid than suturing and giving a satisfactory percentage of "take," was time consuming. The skin graft edges tended to curl under, and

\* From the North Carolina Orthopedic Hospital, Gastonia, N. C.

the graft would retract some because of its inherent elasticity.

Rank<sup>2</sup> has suggested placing the split thick graft on *tulle gras*, a composition of vaseline and balsa of peru on gauze, using this as a carrying vehicle for the graft; but he advocates suturing the carrying vehicle to the recipient area. However, he states that on occasion he has maintained the graft in position without suture fixation.

During the past months we have used the vaseline gauze contact fixation of split thickness grafts on twelve patients. This method is more rapid than any method we have used to date, and the percentage of "takes" has been consistently good.

#### METHOD

Sterile vaseline gauze strips are made up in the following sizes: 5 by  $11\frac{1}{2}$  inches and 10 by 23 inches, as well as the routine 3 by 10 inch size. If a large granulating area is to be covered, full drum grafts are obtained via the Padgett dermatome (full drum grafts measure  $4\frac{1}{2}$  by 10 inches). Hemostats are clipped onto the skin graft borders while the graft is still on the dermatome drum. During the above procedure the surgical nurse flattens out a  $5\frac{1}{2}$  by 11 inch sterile vaseline gauze on two unfolded sterile sponges which in turn have been placed side-by-side on a large sterile, towel-covered wood block. The skin graft is then taken off the dermatome drum using the hemostats as handles. The graft is next placed on the sterile vaseline gauze allowing a one-inch border of vaseline gauze around the graft, the *stratum corneum* layer being in contact with the vaseline gauze. The center portion of the skin graft is then gently pressed onto the vaseline gauze by means of a hemostat. Sulfa-thiazole powder is then sprinkled on the raw graft surface. All hemostats are then taken off one of the narrow skin graft ends, and a picture roller is guided across the graft under constant firm pressure. As the roller meets hemostats still clamped to the graft, the instruments are removed. (Fig. 2.) When the picture roller has reached the

distal end of the graft, it is found that the skin graft adheres firmly under some tension to the vaseline gauze with no tendency



FIG. 1. Patient five years after skin grafting. Pinch grafts were used on left chest; Padgett grafts were used on right chest. Note poor cosmetic appearance of pinch grafted area.

for the skin edges to curl. (Fig. 3.) In the absence of a picture roller the graft can be easily pressed onto the vaseline gauze by Kelly clamps, care being taken not to allow the vaseline to get on the raw graft surface. The entire mass, i.e., skin graft, vaseline gauze and sponges, is then picked up manually and pressed in position over the recipient area. (Fig. 4.) The sterile sponges are then easily removed from the vaseline gauze. Through the transparent vaseline gauze it is a simple matter to place the graft in exactly the desired position in regard to the recipient area, as the graft can be easily observed. (Fig. 4.) When the graft is in the correct location, the vaseline gauze is gently pressed onto the underlying skin graft, and the overlapping vaseline gauze borders adhere nicely to the healthy skin borders surrounding the recipient region; no sutures are used. Pressure dressings are then applied and held by stockinette



FIG. 2.

FIG. 3.



FIG. 4.

FIG. 5.

FIG. 2. Graft removed from drum and placed on prepared vaseline gauze. The picture roller is then guided over the skin graft under constant firm pressure. Note sulfathiazole crystals on raw graft surface.

FIG. 3. The skin graft adheres to the vaseline gauze via the viscosity of the petroleum. Note no curling of graft edges and no loss of size of graft because of inherent elasticity.

FIG. 4. Skin graft and vaseline gauze are placed over the recipient area and pressed in place. No sutures are used. Note translucency of vaseline gauze allowing observation of underlying graft.

FIG. 5. Pattern graft being cut from original graft adhering to vaseline gauze.



FIG. 6. A and B, patient before skin grafting; burn injury.

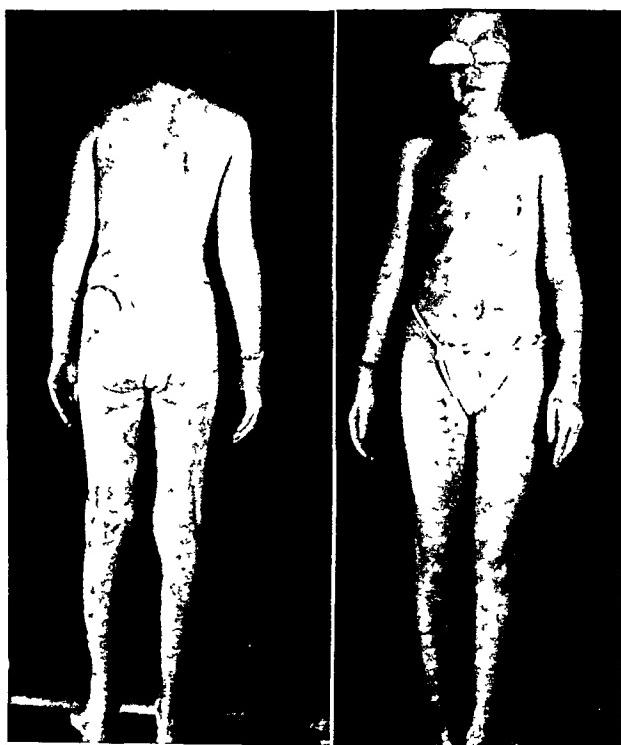


FIG. 6. C, patient four months after completion of skin grafting.

bandage. If after the vaseline gauze and graft are placed over the recipient area it is found that small parts of the graft edges

side on the vaseline gauze using the same method as described above. Here the entire patch graft can be moved easily by two



FIG 7 A, patient before skin grafting, burn injury B, patient five months after completion of skin grafting C, patient two years after skin grafting Note blending of grafted skin and normal contour of leg Knee function is normal

overlap the healthy skin, these overlapping portions of the graft and vaseline gauze can be easily cut by scissors and used on other small granulating spots. Thus every bit of skin graft is used in the grafting operation.

If large areas are to be grafted, we use the large 10 by 23 inch vaseline gauze, and place two full Padgett drum grafts side-by-

persons to the recipient area and held in position via the viscosity of the vaseline.

Small pattern grafts can be cut by the dermatome and held to the recipient area by vaseline gauze cut on a pattern slightly larger than the pattern graft itself. If the surgeon does not wish to cut a pattern with the dermatome, it is a simple matter to cut a full drum graft, place the graft on vase-

line gauze and cut the pattern out of the gauze and adherent graft as easily as such a pattern can be cut out of paper. (Fig. 5.) The extra skin obtained after cutting the pattern can be used to cover any other defects or returned to the donor site.

The postoperative care is minimal on our skin graft areas. It is our opinion that the less the graft is disturbed by frequent observation and handling, the better is the percentage of "take." We routinely look at our grafts ten days postoperatively, earlier only if indicated.

#### COMMENT

We have used split thick grafts, obtained by the Padgett dermatome on over eighty patients to date. Many of these patients had been severely and extensively burned and required many full drum grafts to cover the tremendous granulating lesion. On forty-two of these patients the grafts were held on by means of flamed adhesive tape, occasionally with a few reinforcing sutures. On thirty patients the graft was held on entirely by means of silk sutures. The percentage of "take" in both the above groups was satisfactory. On twelve patients the vaseline gauze contact method has been used, the percentage of "take" in this small series has been unusually high, all running above 90 per cent. No matter what method of fixation all grafts were covered with vaseline gauze, abundant sterile cotton and stockinette pressure bandages.

We would like to emphasize the warning mentioned by Padgett in his original paper on the use of the dermatome,<sup>1</sup> to the effect that when large areas are denuded of skin one must watch the patient carefully as the same factors must be considered as when a large amount of skin is lost in a burn. Occasionally, the freshly grafted patient may require a transfusion of blood or plasma because of loss of that substance at the donor skin site. Careful preoperative observation of the patient and a good evaluation of his physical status will in most cases bring the patient through the

postoperative course without significant event.

In preparation for the grafting procedure general surgical principles should be remembered. We believe the patient should have a hemoglobin of 86 per cent or more by the Sahli instrument. We give blood transfusions preoperatively and during the entire healing period when we find the hemoglobin to be below 86 per cent. This undoubtedly aids in the healing process and helps the patient combat infection. We believe, too, that a "high-normal" hemoglobin tends to give the patient a better cosmetic and functional end result, as healing is rapid, and the grafts uniformly have a satisfactory "take" when such a procedure is followed.

We have obtained grafts from the same donor areas as many as three times, and frequently we use the same donor area twice. One may get skin from a previously denuded area approximately one month after the first graft has been taken, if the first graft was less than full thickness. Such a procedure is facilitated by using the Padgett dermatome which can cut uniform thickness grafts. In our extensive cases of burns that possibility has cut down the hospital stay of the patient markedly.

We have on occasion taken full drum split thickness grafts from a previously grafted area. We find the grafted skin from which the new graft is taken reacts exactly as does previously undisturbed skin. The freshly denuded, previously grafted area healed rapidly, and the graft obtained grows nicely to the new recipient region.

#### CONCLUSIONS

1. Pinch grafts are indicated only to cover the smallest of lesions probably not larger than 2 m.
2. The split thickness graft obtained by the Padgett dermatome appears to be most satisfactory to cover small and large defects in the dermis requiring no bulk.
3. To reduce the operating time in skin graft surgery in which split thickness grafts

are used, the vaseline gauze contact method is suggested.

4. A high normal hemoglobin increases the chance for a successful graft "take." Blood transfusions should be given if the patient's hemoglobin is below 86 per cent.

5. Split thickness grafts may be taken from the same donor area numerous times, allowing a suitable interval time for healing.

6. Split thickness grafts may be obtained from a previously grafted area.

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PEDICLED skin grafts may be classified as simple, compound, and lined. A simple graft is composed of skin and subcutaneous tissue. A compound graft contains skin, subcutaneous tissue, and bone, cartilage, or muscle. A lined graft is a simple graft, the under surface of which is covered with epithelium by folding the pedicle or by applying an Ollier-Thiersch graft.

From "Operations of General Surgery" by Thomas G. Orr (W. B. Saunders Company).

# JAUNDICE

## SURGICAL CONSIDERATIONS

STANLEY EISS, M.D.

Clinical Professor and Associate Attending Surgeon, New York Polyclinic Medical School and Hospital; Associate Attending Surgeon, Gouverneur Hospital

NEW YORK, NEW YORK

THE primary question to the surgeon, in cases of jaundice, is the determination as to whether a medical or surgical problem is involved. Such a discriminate selection depends upon what has been called the proper evaluation of positive factors,<sup>14</sup> among which one can place the history, physical examination and laboratory corroboration. The repeated statement that no one factor can be pathognomonic in itself, has been proved in the many statistical surveys that have been made of such cases.

These surveys have shown that 60 per cent or more of icterus cases fall into the so-called surgical jaundice group. Snells<sup>29</sup> figures indicate that 25 per cent of jaundice cases are due to cholelithiasis and associated conditions; 30 per cent are caused by carcinoma, metastatic and primary in the head of the pancreas, gallbladder and ducts; 10 per cent are due to benign strictures of the common duct. This particular survey therefore, shows a 65 per cent surgical group. In Karl A. Meyers study<sup>23</sup> 58 per cent fell into this group, in which 32 per cent were considered malignant, and 26 per cent benign. Such studies have also shown that the jaundiced patient past middle age has a greater chance of having an obstructive type of icterus than a younger individual, and that in women, such an obstruction is most probably due to a calculus, while in man the cause is more often due to a malignancy.

While such generalizations are of value, the case that presents itself rarely follows any fixed rules and should be evaluated only in the light of what one finds. Naturally, a history of exposure to hepatotoxic substances or systemic disease will influence one toward a diagnosis of hepatosis,

unless evidence of obstruction is clearly indicated.

The clinical picture in "surgical" jaundice almost always includes a story of biliary colic, yet it is not impossible that this important symptom may be missing. Pain, loss of weight, marked pruritis, nausea and vomiting, and changes in the color of the urine and stool are historical facts elicited in varying degrees. Weir<sup>34</sup> gives some interesting variations in what one may expect to find in a history of a stone in the common duct. It starts with the story of chronic indigestion of the gaseous type, containing qualitative and quantitative relations to food, together with the occurrence of biliary colic. Yet chronic indigestion may be absent. Colic may be absent or atypical in character and location. The patient may complain of short periods of indigestion and a sensation of fullness, or pressure and aching in the upper portion of the abdomen. At times relief is obtained by induced belching, vomiting or bowel movement. The attacks may occur at any time of the day or night, although nocturnal awaking is suggestive of organic disease. The duration of an attack may be a few minutes or an hour, and may tend to occur with increasing frequency, prolonged persistence and a residual soreness. With time, the patient complains of slight fever or chills, soreness in the upper right quadrant, and even mild jaundice of a transitory nature. Diarrhea, steatorrhea, edema, ascites, and hematemesis, are symptoms which also may be present. Yet one must keep in mind that such histories are not impossible in cirrhosis of the liver and in jaundice as a result of carcinoma of the head of the pancreas and acute pancreatitis.

Meyer and Steigman<sup>23</sup> give a table of the frequency of the more important findings in the history of sixty-two cases of surgical jaundice. They come to the conclusion that the main positive factory pointing to an obstructive cause removable by surgery is a history of biliary colic.

In the physical examination, the jaundice itself may be informative in as much as the obstructive type is a peculiar greenish yellow in contrast to the striking reddish yellow of a hepatosis.<sup>34</sup> The size, consistency and contour of the liver are determined and the presence of tenderness or rigidity noted. Meyers found the liver enlarged in 82.3 per cent of his cases that were malignant and in 68 per cent of the benign ones. Sometimes one finds a palpable enlargement of the gallbladder as well as movability and tenderness. This might be attributed either to empyema, obstruction of the cystic duct or obstruction of the Ampulla of Vater. Note should be made of scars, fistulas, sinuses, splenic enlargement,<sup>15</sup> abdominal masses, enlarged lymph nodes, evidence of bleeding, loss in weight and bile tophi. Of all, however, the enlarged palpable gallbladder is by far the most direct and significant factor. Hangar<sup>18</sup> has tabulated the difficulties of clinical differentiation between obstructive and hepatocellular jaundice:

ATTEMPTED CLINICAL DIFFERENTIATION BETWEEN OBSTRUCTIVE AND HEPATOCELLULAR JAUNDICE

	Hepatogenous Jaundice	Cancer of Pancreas	Common Duct Stone
Age.....	80 per cent over 40	80 per cent over 40	Usually over 40
Initial symptoms	Usually slight at onset	Insidious often no symptoms	Intermittent recurrent
Pain.....	56 per cent	60 per cent	95 per cent
Itching.....	Often absent	Often severe	Present
Weight loss.	None	Average 20 lbs.	Slight
Fever.....	Varies	No aid	Varies; may be Charcot
Enlarged spleen ...	Often	None	None
Glycosuria ..	None	25 per cent	None
Clay stools.	Intermittent	Present	Intermittent

It is readily evident that no hard and fast rule of differentiation can be made, based on either the history or physical examination alone.<sup>15</sup> It is because of this fact that the surgeon is constantly seeking other aids to give him the composite picture necessary for the classification of a case of jaundice as a "surgical" one. Chief among these aids are roentgenoscopic examinations and laboratory tests.

Such an examination of the gastrointestinal tract is valuable in excluding primary malignant lesions that have metastasized to the liver. Occasionally, widening of the duodenal loop may indicate enlargement of the head of the pancreas. Choledochograms are valuable in studying biliary fistulas, and especially patency of the common bile duct if drainage tubes are in place. Meyer and Steigman, in their series, took roentgenograms of the region of the gallbladder, and in none found shadows suggestive of gallstones, yet stones were found in this series in eight out of twenty-seven cases.

Because of these facts, a great deal of emphasis of late has been placed upon laboratory tests as an aid in determining the necessity for surgical interference in cases of jaundice. Most of these tests depend for their efficiency upon the fact that in jaundice the physiology of bile is interfered with. A new cycle is set up different from the normal one and capable of being recognized by laboratory procedures. Other tests are based upon impairment of some normal physiological functions of the liver.

The color of bile is due to several pigments the most important of which is bilirubin. The faint yellow of normal blood plasma and blood serum is probably due to this bilirubin. Normally blood serum contains less than 1.5 mg. of bilirubin per 100 cc., a coloration that is three to six times as intense as an aqueous 1:10,000 potassium chromate solution. This ratio or icteric index may increase to fifteen times before jaundice can be detected clinically by the discoloration of the skin

and sclera. By this index the progress of a case may be determined as far as latency or discoloration is concerned. Bilirubin is excreted through the bile into the intestine where it is converted into urobilogen, but is then resorbed and utilized by the liver to reform bilirubin. Urobilinogen may also be destroyed (oxidized) by the liver normally. When the liver function is impaired, this reconversion is incomplete and urobilogen appears in the urine. Urobilogen may also appear in the urine in severe hemolysis with overproduction of bile pigment. But in jaundice where there is complete occlusion of the common duct as in carcinoma and stone impaction, the bile cannot get into the intestine, with the result that no urobilogen is found in the urine. When urobilogen does begin to appear in the urine, it is an indication that bile is once more entering the intestine.

The Van den Bergh reaction is useful in differentiating between hemolytic diseases and obstruction or liver damage jaundice. Rich<sup>26</sup> has made an excellent summary of the theory presented by Harrop and Barron<sup>19</sup> which to date is the most plausible explanation of this reaction.

According to this theory, pure bilirubin at blood hydrogen ion concentration gives direct or immediate Van den Bergh reaction, but in normal plasma gives the indirect reaction due to the fact that plasma proteins absorb bilirubin thus preventing the pigment from reacting immediately with the reagent. If, however, such substances as bile salts and cholesterol, which are present in small amounts in bile and in increased amounts in the plasma of jaundiced patients, are added to the plasma before bilirubin is introduced or added at the same time as the bilirubin, the Van den Bergh reaction remains direct. This is due to the fact that substances which lower surface tension seem to be absorbed by the proteins more readily than bilirubin is adsorbed. When the protein molecules are covered with such substances, the pigment remains free. Therefore, when

the plasma of a jaundiced person is tested by the Van den Bergh reaction, the direct reaction indicates that whole bile with its bile acids, cholesterol and bilirubin has been regurgitated back into the blood stream from the bile ducts, and also indicates that either an obstruction of the bile ducts or necrosis of the liver has taken place.

If the Van den Bergh is indirect we assume that the bilirubin in the plasma is pigment which the liver has not been able to remove from the blood, the abnormality consisting in overproduction of bilirubin or a depressed excretory function of the liver, or a combination of these two.

The biphasic (indirect-delayed direct) reaction is due to a high degree of pigment retention without regurgitation, or under certain circumstances to biliary regurgitation caused by obstruction or necrosis of liver cells. Rich has formulated his classification of jaundice upon this theory of retention and regurgitation.

The bilirubin elimination test<sup>13</sup> is based on the above theory. One mg. of bilirubin per kg. of body weight is injected into the blood and the length of time required for its elimination from the blood determined. Normally the entire quantity disappears in two to four hours. In disease of the ducts as well as liver cells, it may be retained in the blood for days.

The second group of laboratory tests, namely, those which depend upon some interference with a physiological function of the liver, is also composed of many groups. Here are found tests dealing with sugar tolerance, interference with the deaminizing function of the liver, the rôle of cholesterol and its esters, the enhancement of curtailment of enzymatic activities of the liver, the effect upon the detoxifying mechanism and disruption of plasma globulin relationships.

In the carbohydrate field, Strauss<sup>32</sup> has shown that when 100 Gm. of laevulose is fed on a fasting stomach, 78 per cent of those with liver disease will show the

sugar in the urine; 10 per cent of normal individuals react in a similar manner. Diminishing quantities of laevulose have been used to determine the extent of liver damage, and it has been shown that in some cases of liver damage as little as 25 Gm. will cause excretion in the urine. When galactose is used, only 40 Gm. are fed, and the appearance within five hours of more than 3 Gm. of it in urine, is suggestive of liver damage. Others have modified these tests by doing blood sugars in conjunction with the urine tests, a positive reaction consisting of a blood sugar of 135 mg. or more, with a total rise of at least 30 mg. Glucose, as well as sodium d-lactate, have also been used along these lines.<sup>31</sup>

The synthesis of urea<sup>1</sup> as a test of liver dysfunction, has not been wholly accepted. Some loss of power for urea formation is undoubtedly present. Frey<sup>17</sup> still believes that the urinary excretion of amino acids is important while others have shown that amino acids fed to animals with diseased livers were not excreted in the urine. Yet, tests are still made for leucine and tyrosine<sup>21</sup> based upon Frey's assumption. Still others look for an increase in the blood non-protein nitrogen<sup>24</sup> in parenchymatous liver damage, because of increased protein destruction, although here an associated pathological change in the kidney may be a factor, since damaged tubular cells prevent urea resorption.

Like other organs in the body, the liver takes part in many enzymatic activities. The use of the Ottenberg test for tyrosine depends upon the activity of tyrosinase which oxidizes this amino acid to melanin. When found in the urine of jaundiced patients, tyrosine suggests subacute degeneration of the liver or malignancy, if present in small amounts. Large amounts indicate acute liver autolysis. The status of this test is as yet indefinite.

The enzyme which has received the most attention of late is phosphatase. An increase in this enzyme was noted by Roberts in obstructive jaundice. Bodansky and

Jaffe<sup>6</sup> produced an elevation by ligation of the common duct in dogs. Armstrong and King<sup>4</sup> confirmed this fact and also produced a toxic hepatitis with elevation of the serum phosphatase. Hellman stresses the importance in obstructive jaundice of a rise in serum phosphatase parallel with a rise in serum bilirubin. In contradistinction, in non-obstructive jaundice in which no such parallelism exists, the serum phosphatase remains below 10 Bodansky units despite a continued rise in the bilirubin. Borderline phosphatase readings with moderately elevated bilirubin, favors obstruction. Borderline readings with a very high bilirubin favors nonobstructive jaundice.

In addition to the many functions already mentioned, the liver is also a center for detoxification. Ordinarily, the body's first effort in the elimination of a toxic substance, is to get rid of it as such, namely, by regurgitation, vomiting, diarrhea, or skin excretion or exhalation, depending upon the nature of the toxic substance. Its chemical defense consists primarily of oxidation or reduction, or a combination of these, in order to produce either a less soluble or a less toxic radical. Failing in these efforts, the body has recourse to combination with other radicals such as sulfates, the amino acids, methylation or acetylation, to mention a few.

Many methods have been elaborated along this line, based on the theory that a damaged liver is incapable of fulfilling completely this function. Among the substances used have been, cincophen,<sup>22</sup> thymol and sodium benzoate. Most favored of these and most promising is the Quick<sup>33</sup> hippuric acid test. Its use has confirmed the idea that liver damage<sup>7</sup> may or may not be associated with the obstructive type of jaundice. Quick contends that the test is helpful in differentiating between obstructive jaundice in which the values are normal or high, and catarrhal jaundice in which values are markedly reduced. The ingested sodium benzoate is conjugated with amino acetic acid to form

hippuric acid which is then excreted in the urine. Normally the liver detoxifies enough of 5.9 Gm. fed, so that hippuric acid equivalent to 3 Gm. of sodium benzoate appears in the urine. As a corollary disturbed intestinal absorption may, by giving low excretion values, be diagnosed by this test.

Plasma globulin changes are recent developments in the field of liver function tests. Foremost is the cephalin-cholesterol flocculation tests. These tests are based on the fact that the liver influences the concentration of plasma proteins and the structure of the plasma globulins. When the liver is damaged the concentration of the plasma albumin decreases while the globulin may remain unchanged or actually increase. The normal A/G ratio, therefore, of 2/1 may be changed in chronic liver damage to 1/1 or even become reversed, accompanied by a general reduction of the total plasma protein. Apparently some change of the plasma globulin occurs in acute liver damage. The cephalin-cholesterol flocculation test is one in which pathological globulins flocculate a cholesterol-cephalin emulsion in varying degrees. The Hanger test<sup>18</sup> which is based upon this principle is simple enough, since it merely consists in mixing normal saline, serum and the antigen, allowing the tube to stand twenty-four or forty-eight hours, with a notation of flocculation and precipitation at the end of these intervals. With normal serum the antigen emulsion remains stable and homogeneous, but the sera from patients with diffuse hepatitis cause a flocculation and precipitation of the lipoidal material.

Another plasma globulin test is in the colloidal gold reaction in which the pathological globulins precipitate and change characteristically the color of the gold chloride. In the Takata Ara test, the pathological globulins flocculate and alkaline sublimate solution in serial dilutions.

The early globulin changes in acute hepatitis can be elicited by the cephalin cholesterol reaction and by the colloidal

gold test. The Takata Ara test, however, becomes positive only in chronic liver disease.

Finally, we have the group of dye tests which probably enjoy the greatest popularity. These depend for their efficacy upon the ability of the liver to remove them from the general circulation and, in some instances, to excrete them into the bile passages. The rapidity with which this removal takes place is utilized as an indicator of the functional activity of the liver.

The following table (Table 1) gives an idea of the numerous dyes that have been tried and the material tested for their rate of excretion:

TABLE I

Intravenous Dye	Duodenal Fluid	Sera
Congo red	X	
Indigo carmine	X	
Rose bengal		X
Azorubin S	X	
Phenoltetrachlorphthalein		X
Bromsulfalein		X
Phenoltetraiodophthalein		X

Of these, only the last four are in popular use today. In obstructive jaundice, with block of the common duct from stone or other external causes, the retention reaches a high figure, not because of hepatic insufficiency, but because of mechanical interference with the channel of elimination. The phenoltetraiodophthalein is considered to have more value because larger doses can be used and simultaneous cholecystographic studies made. Normally only 5 per cent of this dyestuff is retained in the blood after an hour. Excessive retention is indicative of liver damage. These tests<sup>3,9,27,28</sup> are used mainly in differentiating between benign and malignant obstructive jaundice. In malignancy there is very little dye retention, while in inflammatory obstructive jaundice much of the dye is retained, the amount increasing with the length and duration of the

icterus. The explanation given is that in malignancy there is no liver degeneration, whereas in inflammation there is.

The following tabulation (Table II) is a brief resume of findings by the use of these various tests:

TABLE II

	Type of Jaundice*		
	Obstructive		Non-obstructive
	Benign	Malignant	
Test used:			
Urobilogen (in urine and stool) .....	None† Rise	None† Rise	Present Rise usually less marked Low
Bilirubin (in blood).	Normal or low	Normal or low	
Sugar tolerance (of liver).	Rise	Rise	
Serum phosphatase.....	Low	Normal or high	
Detoxification (by liver).			
Abnormal plasma globulins..	None	None	Present
Dyes (intravenous).	Retention in blood	Very little retention in blood	

\* The table assumes that a "pure" type of jaundice exists. Clinically, this is seldom the case.

† In ordinary qualitative test.

Just how important the effect of jaundice is, can be gleaned from the fact that a recent analysis of 4,000 operations on jaundiced patients showed that 16 per cent of the fatalities were due to postoperative hemorrhage. It is generally agreed that the hemorrhagic diathesis of jaundice is due to a lowered prothrombin level of the blood. This factor is always consistently low in jaundiced patients who demonstrate a bleeding tendency. Up to the time of the work of Dam and Almquist,<sup>10,2</sup> the cause of this was a mystery. These and other workers have demonstrated that vitamin K present in the intestine of man is elaborated by bacterial activity. It was shown that vitamin K is absorbed from the intestine

in the presence of bile, the absorption occurring mostly in the jejunum. The vitamin then unites with some intrinsic factor of the liver concerned with the synthesis of prothrombin.<sup>25</sup> The most frequent condition predisposing to a lowered prothrombin level seems to be the absence of bile in the intestine, as in cases of obstruction of the common duct by neoplasm, stricture, stone or complete biliary fistulas. Theoretically, injury to the hepatic parenchyma should interfere with the metabolism of prothrombin. Practically, this is rare because almost 85 per cent of the parenchyma must be destroyed to affect the prothrombin metabolism. But one must remember that repeated administration of intravenous fluids in the presence of hemorrhage and the continued aspiration of bile from the gastrointestinal tract should be followed by prothrombin tests to determine the effect upon the clotting activity of the blood. Work on the chemical constitution of vitamin K has shown that a great number of compounds have similar biologic activity.<sup>2,3,8,11-16,30</sup> Almost all of them are derivatives of the double ring nucleus of naphthalene.

#### SUMMARY

It was pointed out that in so-called surgical (obstructive) jaundice, a history of biliary colic is usually obtained and is the main factor pointing to a surgical condition. A history of chills and fever and light-colored stools may also be obtained. Tenderness and rigidity of the right upper abdominal wall may or may not be present.

However, no hard and fast rule, based on either history or physical examination can be made to select those cases in which operation is indicated. Because of this difficulty laboratory tests based on disturbances of normal functions of the liver are often indicated and helpful in making a diagnosis. These tests of function fall into several main groups: (1) *Secretion of bile*: bile and urobilinogen in urine, icteric index

of blood, Van den Bergh tests of blood; (2) storage of carbohydrate: glucose or galactose tolerance tests; (3) excretion or secretion of enzymes: phosphatase in blood; (4) detoxifying: formation of hippuric acid from sodium benzoate; (5) abnormal globulin formation: cephalin-cholesterol test; (6) dye excretion: bromsulfalein retention; and (7) storage of vitamin K and prothrombin formation: prothrombin level of the blood.

Even in the most probable acute surgical cases, a preliminary period of four to six hours for parenteral administration of salt, water and glucose is necessary. Glucose replenishes the glycogen reserves of the liver and protects its cells. Vitamin K is also given to control the bleeding tendency in jaundice. Moderate amounts of protein in the form of plasma or amino acids help liver regeneration.

In those patients whose clinical picture is less acute, conservative management with salt, water, glucose, vitamin K and protein may result in the clearing up of jaundice which was due to industrial or other poisons or cirrhosis. Laboratory tests may not be able to differentiate obstruction, cirrhosis, stone in the common duct, liver abscess, metastases to the liver, or carcinoma of the common duct or head of the pancreas. Therefore, persistent signs of obstruction such as jaundice, light-colored stools, bile in the urine and a positive direct Van den Bergh test will require eventual surgical exploration.

Even when the decision to operate is difficult to make, preliminary therapy as outlined above builds up the general condition of the patient, while at the same time a few key laboratory tests can be carried out.

It is emphasized that obstruction of the biliary tract often co-exists with damage to the liver cells so that laboratory tests may not be clear-cut. It is in these cases

that judgment and experience decide the course to be taken.

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# WOUND HEALING†

AN EXPERIMENTAL STUDY OF WATER SOLUBLE CHLOROPHYLL DERIVATIVES IN CONJUNCTION WITH VARIOUS ANTIBACTERIAL AGENTS

LAWRENCE W. SMITH, M.D. AND ALFRED E. LIVINGSTON, PH.D.  
PHILADELPHIA, PENNSYLVANIA

In a previous report, certain preliminary experimental studies concerning the effect of the water-soluble derivatives of chlorophyll\* upon wound healing were presented. It was noted that an overall acceleration of healing of about 25 per cent in time was obtained in somewhat over two-thirds of the experimentally induced lesions with the chlorophyll preparations as compared with any of the other twelve test agents and the bases employed in the study. The experimental lesions which were studied in rats, guinea pigs, rabbits and dogs were of three types: first, clean, surgically induced wounds; second, experimentally infected surgically induced wounds; and third, standardized dry heat, third degree burns.

Breaking down the statistical data, it was found that with the chlorophyll preparations the highest acceleration percentage figures were obtained in the case of clean wounds and burns as well might have been anticipated. In specific experiments this acceleration figure ran as high as 83 per cent and in no instance fell below 55 per cent. By contrast in a comparable group of clean cases using the other test agents and controls with their bases, the percentage figures of accelerated healing range from 0 to 50 per cent with an overall average of about 20 per cent, but with a time factor of less than 10 per cent. Indeed, delay in healing, especially with the sulfa drugs, was commonly encountered

in these cases, the percentage varying from 5 to 67 per cent. On the other hand, in the chlorophyll treated group of clean, surgically induced wounds, no delay in healing was noted except in five or six cases in which secondary wound contamination developed as the result of the animal getting his dressing off.

Analysis of the figures from the experimentally infected wounds in these initial studies emphasizes the value of supplementing the wound healing effect of chlorophyll by some antibacterial agent with a wider effective range than chlorophyll alone possesses. It has been shown "in vitro"‡ that chlorophyll has definite bacteriostatic properties, and under suitable environmental circumstances apparently, even some bactericidal capacity; but the action of chlorophyll seems to be more in the nature of enhancing tissue resistance by relative acceleration of the normal repair mechanism, and perhaps by creating an unfavorable milieu for bacterial survival, than by any direct action on the bacteria themselves. This was evidenced by the fact that even in the presence of wound infection acceleration of healing was noted in 63 per cent of the induced lesions treated by chlorophyll alone. With the sulfa preparations alone the picture shifted from delayed healing in over 50 per cent of the clean wounds to acceleration of the repair process in nearly 30 per cent of the infected lesions. The same shift was noted in the series treated by the organic iodine compound, tetrodine, from a delay of about 20 per cent in the clean

\* The chlorophyll preparations used in these studies have been generously supplied us through the courtesy of the Rystan Company, New York City, sole appointee of the Lakeland Foundation of Chicago.

† From the Departments of Pathology and Pharmacology, Temple University School of Medicine, Philadelphia, Pa. Aided by a grant from the Committee on Therapeutic Research of the Council on Pharmacy and Chemistry of the American Medical Association, Chicago Ill.

wounds to actual acceleration in 45 per cent of the infected lesions.

The encouraging results obtained in our

(2) the saving of extremities, (3) the hastening of sloughing of necrotic tissue, (4) the acceleration of healing and (5) the

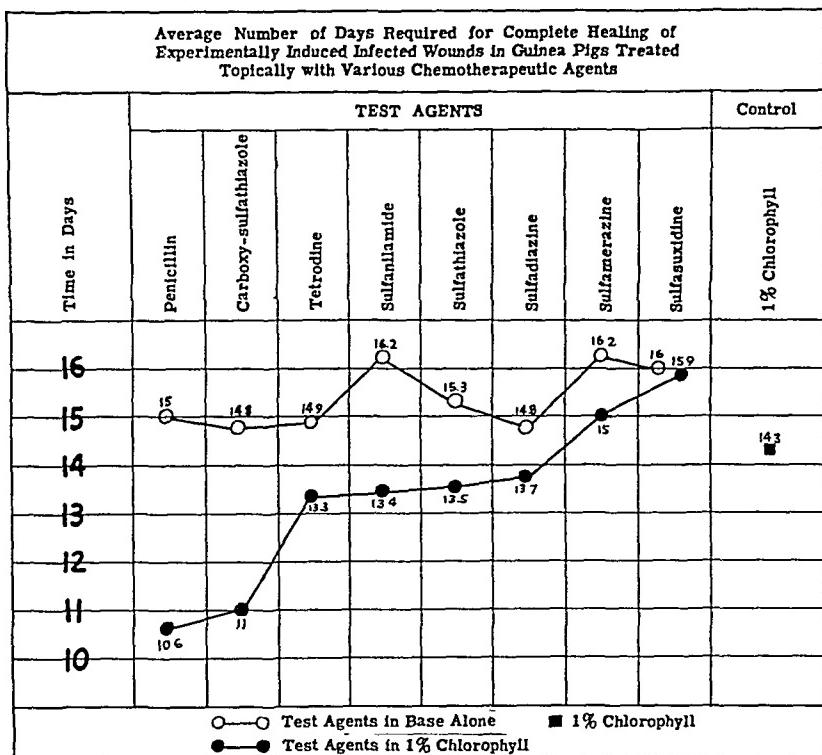


FIG. 1.

preliminary studies with these water-soluble chlorophyll preparations on the healing of burns and infected wounds led us to believe that further investigation in this field, using chlorophyll\* in conjunction with some of the newer antibacterial agents might prove even more fruitful. That the satisfactory treatment of burns and infected wounds still remains one of the major problems not only of the war but also of civilian life can scarcely be denied. Thus, any contribution, no matter how small, which tends to better the results obtained by our present admittedly inadequate methods of treatment, merits serious consideration.

The ultimate aims of any treatment used in such types of injury might be listed as: (1) the reduction of mortality,

reduction in disfiguring cicatrix production by the promotion of normal, soft scar formation. In addition, the saving of time with its economic implications, likewise should be stressed.

It was believed that our earlier studies had definitely established the value of "chlorophyll" as a therapeutic agent in its own right, through its stimulating effect upon normal fibroblastic proliferation,<sup>3</sup> in the healing of burns and infected wounds when treated topically. We had employed the chlorophyll derivatives both in saline solutions as wet dressings and in various ointment and jelly bases, without significant differences in respect to the acceleration of the healing time of the various experimental lesions. In clinical studies the wet dressings were found particularly useful during the first twenty-four to ninety-six hours in cleaning up grossly contaminated wounds. The physical characteristics of the hydrophilic jelly type

\* Whenever the term "chlorophyll" is used in this paper, the water-soluble derivatives are meant, the term "chlorophyll" being used solely for the sake of brevity.

of base were not entirely satisfactory as it tended to dry out, causing the dressing to become adherent and painful unless changed frequently. The oleophilic type base had the familiar objection of merely forming an emollient, insulating layer which did not permit adequate contact of the drug to the actual wound surface.

Thus, we ultimately obtained through the co-operation of various agencies\* an "ideal" ointment base which combined the features of being sufficiently emollient to resist drying out for periods of a week to ten days, while at the same time being sufficiently hydrophilic to release the medicaments incorporated in its substance at a fairly steady, slow rate. In addition several "dusting-powder" types of preparations were likewise used for comparison in the studies.

This search for an "ideal" base involved the testing of several intermediate preparations on guinea pigs before the actual investigation could get under way. In all, somewhat over 200 experimental lesions were observed during the period of their healing, half of them treated by 1 per cent chlorophyll in the particular base under consideration, the other half serving as controls and treated by the base alone. The great majority of these were clean wounds, gross secondary infection occurring in somewhat less than 10 per cent of the lesions. Acceleration of healing of the chlorophyll treated lesions, as compared with the control lesions, by approximately 25 per cent in time was found in this series in 71 per cent of cases as compared with 68 per cent in the earlier reported cases.

Lest the question be raised as to whether the effective agent in these preparations is actually the chlorophyll derivatives and

not some component of the particular vehicle, some thirty additional controls were run, using simple boric acid or petrolatum on the lesions on one side and the several ointment bases, including the base finally adopted, on the other. No difference in the rate of healing was noted under these comparative conditions other than minor variations of a day or so in individual guinea pigs.

With these preliminary background studies serving as controls for the ointment bases, similar experiments were conducted using the 1 per cent "chlorophyll" ointment in combination with various antibacterial agents. Owing to limitations of time our efforts were largely concentrated on certain of the sulfa drugs, penicillin and tetrodine, as representing three of the most generally accepted types of such therapeutic drugs.

Two per cent of the following sulfa compounds were incorporated in the chlorophyll ointment: (1) sulfanilamide, (2) sulfathiazole, (3) sulfadiazine, (4) sulfamerazine, (5) sulfasuxidine and (6) a new experimental product of Lederle's—carboxy-sulfathiazole. In addition, penicillin was employed in the same manner in a concentration of 250 Oxford units per Gm. of ointment. Finally, tetrodine powder was added to the "chlorophyll" ointment to give the recommended strength of 6 per cent free and combined iodine to the preparation with the object of comparing the effect of a true chemical antiseptic with the antibiotic action of the other substances.

The entire study was carried out on guinea pigs, with the exception of a few experiments using dogs for comparative purposes. Twenty-four animals were used in the experiments with each drug. Two symmetrical lesions approximately 1 cm. in diameter were made on opposite sides of the abdomen without any attempt at maintaining surgical asepsis. The wounds were inoculated with a loopful of a twenty-four-hour broth culture of a stock hemolytic staphylococcus (c-209), covered with a

\* We wish to acknowledge our indebtedness to Dr. A. O. Whipple and Dr. E. L. Howes of Columbia University, New York City, for suggestions as to the general composition of a universally satisfactory base, and to Isidor Chamelin, Goldwater Memorial Laboratories, Welfare Island, New York City, Research Fellow of the Lakeland Foundation, Chicago, for the preparation of the ointment bases used in these studies.

simple wet broth dressing to encourage bacterial growth and prevent the animal from licking the lesions clean. The following day treatment was begun. The left hand lesion in each instance was treated with the chlorophyll-antibacterial ointment. The right hand control lesions were divided into three groups of eight each. One group was dressed with the 1 per cent chlorophyll ointment alone, a second group with the ointment base alone, and the third group with the antibacterial agent in the ointment base but without chlorophyll. By this means it was believed that all possible sources of confusion in respect to the several factors involved could be eliminated. An initial tracing of the lesion was made and similar measurements recorded each time the wounds were dressed at two- or three-day intervals until healing was complete. No effort was made to determine anything but this one end point—the healing time required in each instance—in much the same practical way in which the great majority of clinical cases are treated and their progress noted. Blood levels of the drugs were not noted except in occasional isolated instances.

The results of these wound healing studies are summarized in Table I.

At first glance, it might appear that the differences expressed by these "average" figures are not sufficiently marked to be of much clinical significance. However, on more careful examination, it becomes apparent that certain differences do exist, which tend to follow a fairly well defined pattern.

In the first place, it has been shown that 1 per cent of the aqueous soluble chlorophyll derivatives added to the ointment base accelerates the healing process in the care of wounds to an appreciable degree. It should be emphasized that this acceleration is even more marked in the larger lesions as observed in the dog experiments and in clinical cases. In other words, the "chlorophyll" itself gives evidence of having a moderate antibacterial action in the presence of infection, as well

as of a stimulating effect upon the wound healing mechanism as shown in the earlier studies comparing the healing rate in lesions treated by base alone and by the base with added chlorophyll.

TABLE I  
AVERAGE NUMBER OF DAYS REQUIRED FOR COMPLETE  
HEALING OF EXPERIMENTALLY INDUCED WOUNDS  
(INFECTED WITH STRAIN C-209 HEMOLYTIC  
STAPHYLOCOCCUS PYOGENES) IN GUINEA PIGS  
AS TREATED TOPICALLY BY VARIOUS  
CHEMOTHERAPEUTIC AGENTS

Test Agent	Control Series		Test Series	
	Test Agent in Ointment Base Alone	No. Le- sions	Test Agent in 1% Chlorophyll	No. Days
Chlorophyll ointment alone			58	14 3
Penicillin (250 units per Gm)	8	15 0	24	10 6
Sulfanilamide (2%)	7	16 2	22	13 4
Sulfathiazole (2%)	6	15 3	21	13 5
Sulfadiazine (2%)	8	14 8	20	13 7
Sulfamerazine (2%)	7	16 2	19	15 0
Sulfasuxidine (2%)	7	16 0	23	16 0
Carboxy-sulfathiazole (2%)	7	14 8	23	11 0
Total—All sulfa com- pounds	42	15 5	128	13 5
Tetradine (6% iodine)	7	14 9	22	13 3

While the average acceleration with the chlorophyll ointment has been shown to be about 25 per cent in time there have been wide variations in individual cases, in some instances as much as 40 and 50 per cent.

In the second place, in no instance was the average time required for healing of the lesions in any of the experiments in which the supplementary antibacterial agent was combined with the ointment base alone as satisfactory as with the chlorophyll ointment alone. Indeed, actual delay in healing was observed in the case of certain of the sulfa drugs, notably sulfanilamide, sulfamerazine and sulfasuxidine. The individual cases show con-

siderable fluctuation in this respect, possibly due to the particular animal's constitutional susceptibility to the drug,



FIG. 2. Note chlorophyll treated lesion (A) entirely healed with control (B) showing little evidence of repair.

or possibly due in some instances to concomitant infection by supplementary secondary sulfa-resistant organisms, but with delay of as much as 50 per cent in time in some instances.

When we turn to a consideration of the experiments in which the antibacterial agent is added to the chlorophyll ointment there are several interesting observations to record. It will be noted that of all the drugs tested, penicillin,\* in the strength of 250 Oxford units per Gm. of the chlorophyll ointment, gave the most brilliant results. The time required for complete healing was reduced from the 14.3 days needed with straight 1 per cent chlorophyll ointment, and fifteen days for the base and penicillin alone to an average of 10.6 days with the chlorophyll penicillin

\* The penicillin used in these studies was the sodium salt prepared by the Charles Pfizer Company and was released to us for experimental purposes through the courtesy of Dr. Chester S. Keefer, Chairman of the Committee on Chemotherapeutic Agents of the National Research Council.

combination, an additional saving of approximately 33½ per cent in time. In this group there were six animals in which healing occurred within eight days. Despite the instability of penicillin, we found that the potency of the drug was reduced only negligibly over a forty-eight-hour period, if the ointment mixture was kept in the refrigerator. (This particular ointment base, containing no water, is particularly well adapted for topical use with penicillin.) (Fig. 2.)

Analysis of the results obtained with 2 per cent of the various sulfa drugs incorporated in the chlorophyll ointment yielded interesting results. The figures 13.4, 13.5, and 13.7 days, respectively, to secure complete healing with the sulfanilamide, sulfathiazole and sulfadiazine preparations plus chlorophyll are so nearly identical that it would be impossible to determine any differences in their therapeutic efficiency by this means. The healing time is reduced somewhat in all three instances as compared with that of the lesions treated by chlorophyll ointment alone. The difference, however, is not striking as in the case of penicillin.

With the sulfamerazine and sulfasuxidine in combination with the chlorophyll ointment the same delay was noted in the healing of the experimental lesions, as was observed when these sulfa drugs were incorporated in the ointment base alone. This would suggest that these drugs are perhaps more irritating when topically applied, or perhaps their slower absorption might explain the delay in controlling the infection. At all events on the basis of these particular experiments they would not appear to be the sulfa drugs of choice for topical therapy in such cases.

On the other hand, a new experimental sulfa compound, tentatively designated as 5-carboxy-sulfathiazole,\* was found to be almost as effective as penicillin when used topically in the same combination with chlorophyll ointment. In twenty-three

\* This product was placed at our disposal through the courtesy of the Lederle Laboratories, New York.

animals the time required for complete healing of the lesions with this ointment was cut down from 14.3 to 11.0 days, or approximately 30 per cent. This particular sulfa compound appears to have a very low toxicity, a slow solubility and has a hydrogen ion concentration approaching neutrality.

TABLE II

Dog #	Test Agent Right side	Healing in Days	Test Agent Left side	Healing in Days
1	Ointment base alone	28	1% chlorophyll ointment	19
2	Ointment base alone	25	1% chlorophyll ointment	23
3	Ointment base alone	31	2% sulfanilamide ointment	34
4	Ointment base alone	27	2% carboxy-sulfathiazole ointment	28
5	1% chlorophyll ointment	21	2% carboxy-sulfathiazole ointment	27
6	1% chlorophyll ointment	24	2% sulfanilamide ointment	30
7	1% chlorophyll ointment	23	1% chlorophyll 2% sulfanilamide ointment	21
8	1% chlorophyll ointment	21	1% chlorophyll 2% carboxy sulfathiazole	18

N. B. Ointment base alone—average 27.9 days. 1% chlorophyll ointment average 21.9 days.

Finally tetrodine,\* a water-soluble organic iodine product which we used in our previous studies, and which we have adopted routinely as a skin antiseptic in our experimental operative animal work, was employed in a similar manner, in conjunction with the chlorophyll ointment. Owing to the necessary low hydrogen ion concentration of the iodine preparation the resultant mixture of the two substances is not permanently stable, but by combining them freshly each time the animals were dressed, it was possible to carry out the studies satisfactorily. It will be noted that the iodine acted in its usual capacity as a chemical germicide, destroying the

\* The Tetrodine was generously supplied us by the Tyler Laboratories, New York.

infecting organisms, and permitting healing to proceed at the accelerated rate noted in the other cases, under the influence of the chlorophyll factor.

#### STUDIES WITH CHLOROPHYLL DUSTING POWDER

A small series of animals were studied in the same way using chlorophyll as a dusting powder. The chlorophyll was milled to 200 mesh fineness and combined in 1 per cent concentration with lactose, calcium lactate, sulfanilamide, carboxy-sulfathiazole, carbowax 4000 (80 mesh), and with glycine and boric acid both alone and with Tetrodine. One animal was used as a control, using the agent alone, without the chlorophyll. Three animals were treated with chlorophyll mixtures. It is our impression that none of these preparations is as satisfactory as the ointments.

#### DOG EXPERIMENTS

Supplementing the guinea pig experiments eight dogs were similarly treated by producing two symmetrical 7 cm. wounds in their backs. We were interested particularly in noting the satisfactory physical characteristics of the chlorophyll ointment, when applied to wounds which were more nearly comparable in size to those encountered clinically, with especial reference to the fact that it did not dry out and retained its emollient features when dressings were reapplied only at five- to seven-day intervals. In addition we were concerned with the comparative rate of healing in the larger type lesion, treated with chlorophyll ointment alone and with the sulfa compounds added. Obviously, it is impossible to draw any definite conclusions from such a small number of animals, but it seems significant perhaps that the results conform in general to those observed in the larger series using guinea pigs.

Table II gives the essential data relating to these dog experiments.

It will be noted that the best result in time was obtained with the lesion

treated by the chlorophyll-carboxy-sulfathiazole combination as was true in the guinea pig lesions. This was followed



FIG. 3. Illustrates the method of protecting dressings on dog's back by special plywood collar.

very closely on an elapsed time basis by the lesions treated by chlorophyll ointment alone, and the combination of chlorophyll and sulfanilamide. The lesion treated by the carboxy-sulfathiazole ointment alone and the controls on which the ointment base alone was used paralleled each other. There was definite delay in the healing of the two lesions treated by sulfanilamide ointment alone. The ointment base itself proved to be entirely satisfactory physically, retaining its emollient features for as long as a week. We believe it is particularly well adapted for clinical use.

Very much the same method was employed in these dog experiments as in the guinea pig studies. The wounds were intentionally contaminated to simulate actual clinical conditions. The chief problem was to keep the animals from getting their dressings off. This was accomplished by means of a wide collar (Fig. 3) made of light plywood, with an adjustable wedge which could be wired

in position to fit the individual animal's neck.

This represented a modification and a distinct improvement over the corrugated cardboard collar previously described by us.<sup>1</sup> The collar did not interfere with the animal's eating, drinking, or lying down. Indeed, the dogs became accustomed to wearing the collars within a very short time, and were not bothered by them in the least. The dressings were held in place locally by adhesive supplemented by a jacket made of unbleached cotton sheeting or toweling with holes cut for the forelegs and then sewed in place on the back as previously described. The same technic was employed in dressing the guinea pigs and proved to be most satisfactory.

#### COMMENTS

The experimental evidence presented in these studies appears to speak for itself and requires very little discussion. It supplements our earlier studies in which the accelerating effect of chlorophyll upon wound healing was compared most favorably with that obtained by a number of other therapeutic agents rather commonly employed for that purpose. However, because of the relatively narrow range of the effectiveness of chlorophyll as an antibacterial agent, but because of its outstanding tissue growth-stimulating effect in wound healing, it was believed it might prove worth while to explore the possible advantages of combining some of the newer, more potent antibiotics with chlorophyll in the topical treatment of wounds. These hopes appear to have been fully justified by the results obtained in these experimental studies.

Critical analysis of the data serves to bring out and confirm several more or less self-apparent facts. It adds to the rapidly accumulating evidence of the tremendous value of penicillin in the treatment of infected wounds by topical application of the drug, as reported by Clark et al.,<sup>4</sup> Florey and Cairns<sup>5</sup> and many others.<sup>6,7,8</sup> It similarly emphasizes the perhaps less

spectacular but equally important place of the sulfonamides in the same field, supplementing the oral or parenteral administration of the drugs. The apparent relationship of the relative solubility of the sulfonamides to their effectiveness in their topical application was brought out with great clarity. The particularly good results obtained with the new experimental carboxy-sulfathiazole member of the sulfa family leads us to believe that it should be given serious consideration in the clinical field, and made the object of thorough investigation of its pharmacologic action.

These studies further confirm our favorable consideration of Tetrodine as a skin antiseptic. Its complete solubility in water, leading to deeper tissue penetration, and its remarkable low tissue irritability, coupled certainly with an equal bactericidal effect to that of tincture of iodine make it an outstanding substitute wherever tincture normally is used.

Finally, these studies augment the data which we have accumulated regarding the place which "chlorophyll" seems destined to fill in our therapeutic armamentarium in the treatment of burns and wounds. All the evidence which has accumulated from animal experimentation seems to point practically incontrovertibly to the growth stimulating effect of chlorophyll upon the development of healthy granulation tissue with concomitant acceleration of healing of both clean and infected wounds, and with the added advantage of the production of soft scar tissue instead of dense cicatrix formation. Furthermore, as shown both by *in vitro* and *in vivo*<sup>2,3</sup> chlorophyll appears to exert a definite bacteriostatic effect in its own right. However, in the case of grossly contaminated wounds, especially those caused by the pyogenic cocci, the addition of penicillin or certain of the sulfa drugs to the chlorophyll preparations results in a noteworthy shortening of the time required for the elimination of the infection, and of the complete healing of the lesion.

In the experiments which we have recorded in this paper, this acceleration of the whole repair mechanism by the combination of chlorophyll with such antibiotic agents gives us the impression of being what might be termed a symbiotic response, rather than merely expressing the simple cumulative effect of the two agents independently. The possibility that the chlorophyll acts in some unexplained manner as a catalyst in the process is suggested as a reasonable explanation of the phenomenon, but one which will require further exploration experimentally to establish.

Concomitantly with these laboratory studies certain clinical observations have likewise been made, all of which tend to confirm the results obtained in the animal experiments and those already reported in the literature. Among the latter should be cited the papers of Buergi,<sup>9</sup> Boehringer,<sup>10</sup> Gruskin,<sup>11</sup> Gahan et al,<sup>12</sup> Wallace<sup>13</sup> and Goldberg.<sup>14</sup> Mention should also be made of Holmes and Mueller's<sup>15</sup> successful use of chlorophyll ointment in the treatment of burns incidental to x-ray therapy. These water soluble chlorophyll preparations have been used in a wide range of clinical conditions. Their greatest value seems to be in three or four general fields of therapy, although because of the broad physiological basis of their action, many other types of disease might equally well be benefited.

Thus far, from the published literature already cited, and the clinical applications of its use with which we are familiar, it seems as if they had proved to be particularly useful in nose and throat work, especially the treatment of chronic sinus disease; in the dental field in the treatment of Vincent's stomatitis and periodontal disease (pyorrhea alveolaris), and in the treatment of burns and wounds. In this latter field the most striking results have been obtained in long standing chronic cases which have been found stubbornly resistant to all other forms of treatment.

It has been the privilege of one of us (L.W.S.) to aid (directly, or indirectly in an advisory capacity to a number of our friends) in the treatment of a number of such chronic resistant cases. These have included several longstanding cases of osteomyelitis, some of several year's duration; at least three burn cases which had failed to heal after as much as eighteen to twenty months previous therapeutic efforts, and a dozen or more cases of indolent ulcers, chiefly of peripheral vascular origin.

In many of these the results have been almost dramatic. Several extremities for which amputation had been urged have been saved, and complete healing has taken place in unbelievably short periods of as little as twelve to twenty days in a few instances.

In the dental field, the results appear to have been equally dramatic. Goldberg,<sup>14</sup> in his paper emphasizes the importance of the water-soluble chlorophyll derivatives in the treatment of oral sepsis, especially Vincent's stomatitis, in which he reports chlorophyll almost a specific. James,\* of Temple University Dental School, confirms Goldberg's findings in a series of some 200 cases of periodontal disease.

#### SUMMARY

1. A preliminary study of chlorophyll in various ointment bases in over 200 experimentally induced lesions in guinea pigs showed acceleration of healing of approximately 25 per cent in time in 71 per cent of the chlorophyll topically treated lesions as compared with those treated by the ointment base alone.

2. Further studies upon a series of 192 guinea pigs with bilateral, symmetrical, infected, surgical lesions 1.0 cm. in diameter similarly treated topically with 1 per cent chlorophyll ointment combined with various of the sulfa drugs, with penicillin, and with Tetrodine were carried out.

3. Twenty-four animals were used in the experiment with each antibacterial agent, the controls being divided into

\* Personal communication—unpublished data.

three equal groups of eight animals; one-third being treated with base alone, one-third with base plus chlorophyll alone, and the final third with base plus antibacterial agent alone.

4. The topical use of penicillin in strength of 250 Oxford units per Gm. of ointment combined with 1 per cent chlorophyll gave the most spectacular results, with healing complete in 10.6 days as compared to 14.3 with chlorophyll alone, and 15.0 days for penicillin alone, an acceleration of nearly 35 per cent.

5. The sulfa compounds, in combination with chlorophyll, in general showed some acceleration of healing, through their control of infection which appeared to be roughly proportional to their solubility.

6. Carboxy-sulfathiazole was by far the most effective of these sulfa compounds, nearly equalling penicillin in that respect.

7. Sulfanilamide, sulfamerazine and sulfasuxidine alone in the ointment base actually caused some delay in healing.

8. Tetrodine employed in the same manner was of about the same order of effectiveness as sulfanilamide, sulfathiazole and sulfadiazine.

9. A small series of guinea pigs treated by chlorophyll combined with various agents as a dusting powder gave less clearly defined results and further studies do not seem warranted.

10. Experiments carried out on eight dogs with larger wounds gave comparable results to those described in the guinea pig studies.

11. The ointment base proved to be entirely satisfactory and well adapted for clinical use.

12. A discussion of the clinical possibilities of chlorophyll in combination with the various antibacterial agents is presented, and its importance in the healing of chronic types of ulcerative lesions is stressed.

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# GANGRENE AND PERFORATION OF THE GALLBLADDER\*

C. A. BACHHUBER, M.D.,

Assistant Clinical Professor of Surgery, College of Medical Evangelists

PAUL H. DEEB, M.D.† AND E. A. TAYLOR, M.D.†

LOS ANGELES, CALIFORNIA

IN reviewing the literature on the surgical treatment of gallbladder disease one is confronted with numerous clinical reports, many of which advocate diametrically opposed types of therapy. Similarly, the clinical reports presented as regards the different types of pathological lesions encountered in any series of cases, also show a great variation. The rate of advancement of the pathological process, the dangers of serious complications, and the dangers of certain types of therapy are emphatically stressed by some of the authors.

From the many articles published in the literature it is quite evident that until surgeons who are interested in clinical research become more specific in their reports and analysis, it will remain difficult to reach the proper conclusions from the papers presented.

That there is a marked difference in the application of the terms referring to the surgical treatment of the diseases of the gallbladder goes without saying; for such expressions as immediate, early and late as applied to gallbladder surgery are open to such wide interpretations that it only increases the confusion which already exists as to the method of their application to this disease.

We must also be aware of the fact that the clinical and pathological findings are frequently at wide variation and a similar divergence exists between the surgeon's postoperative diagnosis and the gross and microscopic examination as reported by the pathologist.

Being cognizant of the above, we must realize that reports based entirely upon the clinical diagnosis and the surgical description at the time of operation cannot be given the same credence as one based upon the gross and microscopic description as reported by the pathologist.

Being primarily concerned with gangrene and perforation and their allied pathological states as they pertain to the gallbladder, and attempting to be rather specific in our reports we are at first confronted with the definition of the term "gangrene." It is quite apparent that this term is also rather loosely applied. Since "gangrene" is defined as "anemic necrosis of tissue combined usually with the invasion by saphrophytic organisms," and "necrosis" is defined as "death of a circumscribed portion of tissue," it is quite obvious that the term necrosis frequently is the proper and fitting term to be applied. Since necrosis must be a forerunner of gangrene, the two processes are intimately related and consequently any discourse upon the subject of gangrene of the gallbladder must include any pathological process which predisposes to necrosis which may or may not result in gangrene.

Then the clinical term "acute cholecystitis"—Do we include acute cholelithiasis? How can we make any early differential diagnosis between the two?

Are not the advocates of immediate surgery (defining "immediate" within forty-eight hours after the *onset* of the disease) operating upon patients with a

\* From the Surgical Service of the Los Angeles General Hospital and Department of Surgery, College of Medical Evangelists, Los Angeles.

† Dr. Deeb is now on active duty in the Army of the United States, and Dr. Taylor is with the U. S. Navy.

subsiding acute cholelithiasis and referring to same as acute cholecystitis?

This distinction is rather difficult to determine and naturally one is justified in assuming a lower mortality in a subsiding or retrogressing lesion than would occur in an advancing process; and contrary to the views expressed by Heuer<sup>1</sup> our data accumulated show that an overwhelming majority of these acute attacks subside spontaneously and it is by far the exception that the pathological process progresses to the point of necrosis, gangrene or perforation.

Further, the close observation of the patient will definitely decide whether the process is advancing or regressing and surgery can be instituted at any time if need be.

One must also be specific as to the pathological group one is dealing with, for the percentage of gangrene and perforation in a general series is naturally expected to be far below that of a series of patients suffering from acute cholecystitis.

Any student on this subject cannot help being impressed and bewildered by the marked variation in the percentages of gangrenous and perforated gallbladders reported as a result of acute cholecystitis.

Thus Heuer<sup>1</sup> reports a 26 per cent occurrence of gangrene and perforation in his new New York Hospital series and Behrend<sup>2</sup> reports a zero per cent, stating that he has seen but one perforation in twenty-five years and that was in a newly formed gallbladder following a previous cholecystectomy.

Similarly, the mortality resulting from gangrene and perforation shows a like variation in that Alexander<sup>3</sup> reports a mortality of 50 per cent in acute perforation and 25 per cent in subacute perforation while Heuer<sup>1</sup> reports a mortality of 12.5 per cent in a series of sixteen cases with demonstrable perforation of the gallbladder, fifteen of which had an extra-cholecystic abscess and one with generalized peritonitis.

Although Heuer does not state the

number of free and walled-off perforations in this series, we believe that we are justified in assuming that the fifteen with the pericholecystic abscess were walled-off perforations and possibly the patient with generalized peritonitis had a free perforation. His mortality as reported in a series of 153 patients with cholecystitis operated upon during the acute phase, forty of which showed areas of gangrene and sixteen with perforation was 3.2 per cent.

It is this marked variation in the occurrence of gangrene and perforation of the gallbladder and the resultant variation in the mortality rates that prompted us to undertake a study of gangrene and perforation of the gallbladder and allied conditions.

Needless to say there are many points that are in need of clarification and until universal terminology as applied to the surgical treatment of diseases of the biliary tract is adopted it will remain difficult properly to evaluate the reports presented by the students on this particular subject.

To cover the topic properly we have divided all the patients admitted for acute cholecystic disease or those that were admitted after subsidence of the acute attack exclusive of tumors, into two main divisions, namely, those patients treated medically and those treated surgically.

Under the diagnosis of acute cholecystitis we are grouping all patients who were admitted during an acute attack of biliary disease and we are not attempting to differentiate between acute cholelithiasis and acute cholecystitis. We do emphasize the fact, however, that the attack was of such severity that hospitalization was considered emergent.

The surgical subdivision was reclassified into four groups: (1) ulcerative cholecystitis, (2) infected hydrops or so-called empyema, (3) necrosis or gangrene without perforation, and (4) perforation.

The perforative group was further subdivided into (1) healed perforation or internal biliary fistula, (2) walled-off perforation or pericholecystic abscess, and (3)

free perforation. Our review covers the admittances to the Los Angeles General Hospital over a period of four years, namely, from January 1, 1938 to January 1, 1942.

During this period there were admitted for treatment to the Los Angeles General Hospital a total of 1,699 patients suffering from an acute attack of biliary disease or giving a history of a previous acute episode. Of this number, 895 were admitted to the medical service during the acute phase and later were either dismissed, the acute episode subsiding, or were transferred for elective surgery or died. Eight hundred four were operated upon, being transferred for elective surgery, or readmitted at a later date as ambulatory patients for elective surgery. One hundred fifty-four were admitted as ambulatory elective patients but with a history of previous acute attack.

The surgical group contains all that were operated upon, and, in order to avoid duplication all in this group that were transferred from medicine for elective surgery are not included in the medical group.

In view of the high percentage of gangrenous and perforated gallbladders reported and the stress placed upon the dangers of these pathological conditions it was decided to analyze first the group which was treated medically.

Since all in this group (895) were admitted with a diagnosis of acute or recurrent attack of cholecystitis or cholelithiasis and none were operated upon, we believed that this would give us some definite information as to the dangers of gangrene and perforation with the resultant mortality.

In this group we have placed all patients admitted with an acute syndrome which was more or less typical of acute biliary tract disease (acute cholelithiasis or acute cholecystitis) and of such severity to warrant admittance to the hospital. The majority of the staff at this institution favor the delayed type of therapy (waiting for subsidence of the acute symptoms and performing the surgery during the quies-

cent stage). Consequently, all patients with this syndrome are admitted to the medical service with the exception of those in which immediate intervention is contemplated. These are admitted direct to the surgical service. Any of course that are in need of emergent care after reaching the medical service are promptly transferred to the surgical service.

None in this entire group were subjected to surgery for one of the following reasons: (1) The patient was moribund upon admittance, (2) the patient was suffering from some concomitant disease of such severity that the surgeon refused to operate, (3) the patient refused surgery, or (4) the patient was dismissed and told to return at a later date for elective surgery. Many of these patients had had a previous admittance for acute cholecystitis with spontaneous subsidence of the attack and an overwhelming majority gave a history of previous similar attacks.

We must frankly acknowledge the possibility of error in the clinical diagnosis, but since by far the greatest percentage of deaths had a necropsy performed the results of which substantiated the clinical diagnosis, we believe we are justified in concluding that the clinical diagnosis was correct in a very high percentage of all the cases studied.

Of the total of 895 non-operative patients admitted to the medical and surgical service with a diagnosis of acute cholecystitis fifty-two died, which represents a non-surgical mortality of 5.81 per cent.

Here is a group of approximately 5.81 per cent to which little, if any, attention is paid as far as reduction of mortality is concerned. If both the advocates of delayed and immediate therapy would focus their attention upon this group, a substantial reduction of mortality could be achieved. By far the greatest percentage of these patients have had previous acute attacks and until this group of patients is brought to surgery at an earlier age, little in the actual reduction of mortality can be expected; for there is no doubt that therapy

instituted at an earlier age whether it be immediate, early or delayed would show considerable reduction in the death rate. Just as the death rate of appendicitis has been reduced by educating the public into recognizing the symptoms and the advantages of early surgery, just so, in a similar manner, the education of the public as to the value of surgery at the earliest possible opportunity in case of gallbladder disease will achieve similar results.

In analyzing the non-surgical deaths we find the following: 69.23 per cent of the deaths occurred in patients over sixty-three years of age; 48.07 per cent of the deaths occurred within seventy-two hours after admittance; 34.7 of the deaths were due to common duct obstruction with its sequelae; 17.13 per cent were admitted in coma or semi-coma. With but few exceptions these patients had repeated attacks of biliary colic and inflammation of the biliary tract. Practically all of these patients had some serious concomitant disease. However, of these fifty-two deaths only twenty-two were due to gangrene and perforation which brings the mortality to 2.45 per cent.

When we consider the fact that the overwhelming majority of these patients had one or more previous attacks with spontaneous recovery we believe that we are justified in concluding that the danger of death due to gangrene or perforation in non-surgically treated patients is far less than 1 per cent.

Nevertheless this entire group represents a considerable mortality for whom little has been attempted and much should be done. This must be considered a so-called forgotten group.

One must also be appraised of the fact that all these patients either refused surgery, or the surgeon refused to operate because of the presence of some other pathological condition, or the patient was moribund upon admittance to the hospital. Therefore, these deaths represent a group more or less beyond surgical help, for certainly better physical conditions may have

spared some lives by surgical intervention which would lower the mortality of the medically treated group. Many of these have also had previous admittances for acute cholecystitis and almost all gave a history of one or more previous acute attacks.

These figures show a marked variation as compared to the statistics presented by the following: Thus, Clute<sup>4</sup> encountered 14 per cent with gangrene and perforation, Kernath<sup>5</sup> 27 per cent and Heuer<sup>1</sup> 26 per cent.

The remaining 804 patients were admitted to the surgical service with an acute attack or having a history of having had one or more previous acute attacks.

As previously stated we have divided the surgical patients studied, into four groups. Since superficial ulceration means localized necrosis and, necrosis loosely applied means gangrene, we believe that in a study of gangrene and perforation, this group deserves attention; for the localized areas of gangrene and perforation probably are always preceded by ulceration of the mucosa.

In group two we have placed infected Hydrops which is developed through obstruction of the cystic duct. This pathological condition undoubtedly preceded many of the perforations and probably many of the pathological states in which the entire gallbladder becomes gangrenous. Indeed it is quite possible that in cases of perforation some type of obstruction is always present.

In group three we have placed all the patients suffering from some form of necrosis or gangrene of the gallbladder without perforation and in group four we have placed all the perforations.

The perforative group was again subdivided into (1) healed perforation or internal biliary fistulas, (2) localized perforation or pericholecystic abscess and (3) free perforation.

In our study we have accepted the pathologists report, if available, as the final diagnosis. Needless to say the clinical report, the surgical report, and the patho-

logical report frequently showed a wide variation and we believe that in presenting statistics of this type the pathological report must be accepted as final.

In the first group, that of ulcerative cholecystitis, including the healed process, we have a total of 115 patients which represents 6.76 per cent of the total admittances of patients with an acute attack of biliary disease or having a history of one or more previous acute episodes. Of these all but twenty-one were admitted with an acute attack and surgery performed in the interval, and all but one had a cholecystectomy. There were four deaths or a mortality of 3.44 per cent.

All deaths were females, their ages being fifty-two, fifty-nine, sixty-three and seventy-five. All were operated upon after the subsidence of an acute attack and were in the so-called elective group.

This group presents unmistakable evidence that gallbladder disease is reversible disease and in far the greatest percentage of instances regardless of the fact that superficial ulceration or necrosis is present the pathological process tends toward spontaneous resolution.

Since this mortality is less than one-half of the reported general mortality of 7.06 per cent at this institution,<sup>6</sup> it is possible that as far as this group is concerned the ulcerative lesion to a certain extent may have improved the patients' resistance, thereby preventing postoperative complications which lead to a fatal outcome.

#### INFECTED HYDROPS OR SO-CALLED EMPYEMA OF GALLBLADDER

Since obstruction of the cystic duct whether due primarily to inflammation or secondary to stone is directly responsible for hydrops formation and an infected hydrops must be considered as potential perforation unless the internal pressure is relieved, we have therefore included this group in our study. The necrotic process may be either localized or generalized depending upon the type of a pathological lesion which is encountered.

In this group we have sixty-nine patients who were admitted during an acute attack and operated upon either as emergency or elective patients, or were later readmitted for elective surgery. Of these, fifty-six were subjected to some type of surgical procedure and the remaining thirteen were not operated upon for various reasons.

Of the thirteen non-operative patients four died, a mortality of 30.76 per cent. Three of these patients were females and one a male the ages being as follows: fifty, fifty-two, fifty-three and eighty-one. The first patient was admitted in diabetic coma, the second had extensive carcinoma of the breast, the third glomerulonephritis with uremia and the fourth refused both study and surgery. Of the fifty-six patients subjected to surgery, four died or a mortality of 7.10 per cent.

In further analysis of this group we find that twenty-six patients had a cholecystectomy and thirty patients had a cholecystostomy. These groups were further subdivided into those who received emergency surgical care and those who were finally operated upon as elective patients.

Of the twenty-six cholecystectomies, ten were performed as an emergency, and sixteen as an elective procedure. Of these performed as elective procedures there were no deaths and of those performed as an emergency procedure there was one death, a mortality of 6.25 per cent. Of the thirty cholecystostomies, seven were performed as elective procedures without a death and twenty-three were performed as emergency procedures with three deaths, or a mortality of 13.04 per cent. These three patients were desperately ill at the time of admittance and immediate emergent surgery was performed, the ages being fifty-nine, sixty-seven and seventy-six, the latter being a female.

Apparently in further analyzing this group, with the possible exception of the death from an emergency cholecystectomy which may possibly have been avoided by performing a cholecystostomy, the only

possible opportunity of reducing the mortality in this group is by earlier hospitalization for surgery or interim surgery. Here again, immediate, early or delayed surgical treatment would not reduce the mortality, but education of the patients to seek earlier medical attention, and stressing to the profession the necessity for early hospitalization for study or surgical care would, no doubt, have a beneficial result.

#### GANGRENE

In the group in which gangrene was diagnosed by the surgeon we have a total of twenty-six patients representing 1.53 per cent of the total admittances with an over-all mortality of 12.5 per cent.

The age and sex of the surgical deaths were as follows; male, forty-eight, admitted in coma and was an old hemiplegic with a history of two cerebral vascular accidents, operated the day of admittance; male, fifty-seven, operated nineteen days after admittance but eviscerated which resulted in this patient's death; male, sixty-three, operated seventeen days after admittance, the postmortem diagnosis being uremia and acute necrosis of the liver with an area of necrosis in the gallbladder. Undoubtedly, the reason for delaying surgery in two of the above was a question of improving the patients' physical condition. The two non-surgical deaths occurred the day after admittance.

Certainly all five of these deaths were unavoidable as far as the treatment at the time of admittance was concerned and could have been avoided only by bringing these patients to surgery at a younger age.

In this group there were six cholecystostomies with one death or a mortality of 16.66 per cent, while in the group of eighteen cholecystectomies there were two deaths with a mortality of 11.11 per cent. Here again the possibility of a cholecystostomy performed in place of cholecystectomy may likely have reduced the mortality, but the fundamental cause for the deaths was that these patients did not come to surgery at an earlier date.

#### INTERNAL BILIARY FISTULA

In this group (4A) we have a total of thirteen patients or .76 per cent of the total admittances. There were six deaths representing an over-all mortality of 46.15 per cent. However, of this group, nine were subjected to surgery with two deaths, or a surgical mortality of 22.22 per cent, while four were not operated upon with a mortality of 100 per cent.

The ages and sex of the operative deaths being female, sixty-two, female sixty-four, and the cause of death in both being intestinal obstruction. Of the non-operative deaths all patients were in extremely poor condition and the age, sex and cause of death were as follows: male, age eighty-seven, perforation of bowel due to gallstone; female, sixty-nine, died day of admittance, choledochoduodenal fistula with ascending cholangitis with multiple liver abscess; male, age one-hundred, died day after admittance of a cholecystogastric fistula with common duct stone with obstruction, and a male, age sixty-eight, intestinal obstruction due to gallstone. As one will note the age group of the non-operative deaths is in the higher brackets, all poor risks and the preoperative diagnosis rather obscure at times. All these patients undoubtedly have had previous biliary tract symptoms.

The possibility of intestinal obstruction due to a gallstone must always be considered in any acute abdominal condition particularly if a history of jaundice is obtained.

This group which represents but .76 per cent of the total admittances again presents a mortality group which can expect very little help of immediate, early or delayed type of therapy but will be aided only by bringing these patients to surgery at an earlier age or date.

Eight of these patients had the pre-mortem diagnosis of intestinal obstruction due to gallstone correctly established.

#### PERICOLECYSTIC ABSCESS

In this group (4B), namely, that of pericolecystic abscess or walled-off per-

foration we are dealing with an active, acute, pathological process which may have subsided clinically. This type of lesion probably is produced from localized ulceration followed by necrosis of a localized area of gallbladder with resultant perforation. This perforation may occur into the liver substance itself or into the surrounding organs, particularly into the omentum which became adherent to the gallbladder serosa before actual perforation occurs.

In this group we have a total of eighteen patients representing 1.05 per cent of the total admittances. Of these, seventeen were subjected to surgery with one death or a mortality of 5.88 per cent. However, the total mortality was 11.11 per cent, there being two deaths, one of which was non-surgical. In the surgical group there were four males and thirteen females, the age groups being as follows:

20-29	30-39	40-49	50-59	60-69
1	4	2	3	7

The non-operative death had had a diagnosis of cirrhosis of the liver and carcinoma of the head of the pancreas previously made with the peritoneoscope. This diagnosis was disproved at autopsy, the cause of death being due to a common duct stone and perihepatic abscess. This entire group of patients all gave a history of previous acute attacks.

Here, again, we have a surgical mortality of 5.88 per cent which is lower than the average mortality of 7.06 per cent as previously reported by one of us.<sup>6</sup> Seven or 41.17 per cent had a cholecystectomy and seven or 41.17 per cent had cholecystostomy while three or 17.65 per cent had simple drainage of the abscess.

The only death was that of a sixty-four year old male who had but a simple drainage of the abscess. This patient was operated upon ten days after admittance. Certainly a more simple procedure could not have been performed but the possibility of earlier surgery may have spared

this life; yet as a whole the surgical mortality of this group was smaller than the mortality of a general operative series.

#### PERFORATION

This group (4c) which ordinarily represents the one with the highest mortality contained a total of thirty-three patients representing 1.94 per cent of the total group. There were fourteen deaths or a mortality of 42.42 per cent. There were twenty-two operative patients with three deaths or a mortality of 13.63 per cent. As expected, the non-operative mortality was 100 per cent.

This group and pericholecystic abscess should possibly be considered together but in this group a perforation of the gallbladder was described by the surgeon while in the pericholecystic abscess group no perforation was described, the perforation probably having sealed or not found.

The age groups were as follows:

20-29	30-39	40-49	50-59	60-69	70-79
1	0	5	9	6	12

Thus, 81.81 per cent of the perforations occurred in the group over fifty-two years of age and over 57.57 per cent occurred in the age group over sixty years of age.

The surgical deaths with the exception of one patient, a female who was operated upon as an elective patient and died from gangrene of the abdominal wall at the age of forty-four were in the advanced age group, their ages being sixty-nine, seventy-one and seventy-three, respectively.

In the non-surgical deaths, ten in number, 60 per cent were seventy years or older.

Here, again, is a group of patients, ten of whom died, without surgical intervention which represented a total of 71.42 per cent of the mortality.

Certainly, regardless of the type of therapy instituted little reduction in mortality could be obtained; bringing these patients to surgery at an earlier age un-

doubtedly would contribute tremendously toward the reduction of the mortality.

#### COMMENTS

This entire series represents a total of 1,699 patients admitted during an acute attack of biliary tract disease or who were admitted for elective surgery following the subsidence of the disease.

Of this total 115 or 6.76 per cent were found to be suffering from superficial or healed ulceration, thirty-four or 2.0 per cent from gangrene, fifteen or .88 per cent from internal biliary fistula, eighteen or 1.05 per cent from pericholecystic abscess formation and forty-five or 2.64 per cent from free perforation, showing a total incidence of 1.36 per cent of some type of necrosis or gangrene.

Deleting the ulcerative group the incidence of gangrene and perforation among the total admittances is 6.82 per cent. There were twenty deaths among the patients suffering from internal biliary fistulas, gangrene, perichelecystic abscess or free perforation on the medical service and nine operative and eighteen non-operative deaths on the surgical service or forty-seven deaths, making an over-all mortality of 2.76 per cent. Of these deaths, thirty-eight were non-operative which comprised 80.85 per cent of the total mortality, placing the surgical mortality at .53 per cent and the medical mortality at 2.23 per cent.

On the surface the incidence of gangrene and perforation appear rather high but not near as high as some of the statistics previously quoted. Yet in all sense of fairness in reaching the correct conclusions one would have to determine the number of acute attacks each patient in this series experienced to determine correctly the possible danger of gangrene or perforation of the gallbladder. If the average attack per individual be placed at two, this would immediately reduce the danger of gangrene 50 per cent. Although we have no exact figures to prevent, we are of the opinion that the average attack per patient before surgery is instituted is far above two, con-

sequently the danger of some type of gangrene developing from an acute attack is rather small.

However, the deaths from the gangrenous group represent a mortality which must be reckoned with, but by far the most important group in the reduction of mortality from biliary tract disease is the non-operative or the forgotten group, a group about which little is heard, while the exponents of the different types of surgical therapy expound the virtues of each. If the adherents to the different types of therapy would pause but a moment and give this group the proper consideration, a substantial reduction in the mortality of disease of the biliary tract could be obtained. The proper education of the public to the fact that the removal of a diseased gallbladder is necessary as soon as possible will undoubtedly stave off some of the serious complication at a later date, and be a marked contribution toward the lowering of this mortality.

For the more recurrent attacks the patient has, the older the age, the more likely it is that the patient may also be suffering from some serious concomitant disease all of which will contribute to the mortality.

#### CONCLUSIONS

1. The danger of gangrene and perforation is overstressed by the group that favors immediate surgery.
2. Neither delay nor early surgery will spare the patient who seeks hospitalization when he is moribund.
3. Greater attention should be paid to the forgotten group through proper education, thereby bringing the patient to surgery at an earlier age.

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# TUBERCULOSIS OF THE BREAST\*

REPORT OF NINE CASES INCLUDING TWO CASES OF CO-EXISTING CARCINOMA AND TUBERCULOSIS

ROLAND I. GRAUSMAN, M.D.

AND MEYER L. GOLDMAN, M.D.

Associate Attending Surgeon, Hospital for Joint Diseases

Assistant Adjunct Surgeon, Hospital for Joint Diseases

NEW YORK, NEW YORK

THE purpose of this paper is to add nine additional cases of mammary tuberculosis to the literature, including two cases of concurrent tuberculosis and carcinoma of the breast.

*History.* Since Sir Astley Cooper, in 1829, first described the condition as "scrofulous swelling of the bosom" there had been approximately 500 reported cases in the literature, and several excellent articles reviewing the subject are listed in the bibliography. As Grimes and Massie<sup>1</sup> pointed out in their article, interest in tuberculosis of the breast lies first in its comparative rarity; second, in the difficulty of making a clinical diagnosis; third, in determining whether the condition is primary or secondary in the breast; and fourth, in determining the portal of entry of the tubercle bacillus. Some of our cases will be discussed with relation to the above points, and a glance at our charts showing our preoperative diagnoses compared to the pathologic findings emphasizes our inability to make a correct clinical diagnosis with any degree of accuracy.

*Incidence.* The incidence of tuberculosis as compared to other lesions of the breast ranges in various series from 0.54 per cent reported by Nicolson and Gillespie<sup>2</sup> to 1.87 per cent reported by McGehee and Schmeisser.<sup>3</sup> Thus roughly one out of every one hundred breast conditions is tuberculous mastitis.

*Etiology.* The tubercle bacillus is the causative agent but the portal of entry is frequently difficult to determine. Invasion of the breast might occur by one

of the following routes: (1) Through the milk ducts by way of the nipple; (2) through abrasions of the skin; (3) by direct extension from the lungs and chest wall; (4) through the blood stream, and (5) through the lymphatics. Interesting cases are cited in the literature to support the various routes above outlined but there is general agreement that in most cases, the tubercle bacillus is carried to the breast by retrograde extension through the lymphatics from tuberculous cervical, axillary or mediastinal lymph nodes. Several of our cases bear out this method of spread. Evidence against the invasion of the breast through the blood stream is found in the work of Negastkima<sup>4</sup> who performed complete autopsies on thirty-four patients who died of miliary tuberculosis. He sectioned the breast and subjected them to microscopic study, smear and guinea pig inoculations without finding a single instance of breast involvement. Trauma may be an etiologic factor in certain rare instances but on the whole plays a minor part. It is agreed that heredity is of negligible importance. Tuberculosis of the breast is most common in women in the age group between twenty and fifty. (In our series the average age was thirty-five years.) Although pregnancy and lactation are predisposing factors in the etiology, about 20 per cent of the women with mammary tuberculosis were single, and approximately 4 per cent of all the reported cases were in male patients.

*Classification.* For practical clinical purposes the disease is divided into the

\* From the Surgical Services of Dr. A. J. Beller and Dr. Milton Bodenheimer, Hospital for Joint Diseases, New York City.

primary and secondary types. When there is no demonstrable evidence of tuberculosis elsewhere in the body, the condition is classified as primary tuberculous mastitis. Most cases are of this type, although there is the possibility that there is a primary focus elsewhere. In the secondary type, there is evidence of tuberculosis in other parts of the body, such as the lungs, bones, pleura or lymph nodes. A useful classification based on the gross pathology divides the cases into three groups:

1. *Nodular.* The tubercle which is usually situated in the connective tissue enlarges to form a lump which may range from 2 to 10 cm. in diameter. As the condition progresses, caseation and suppuration occur and sinus formation may develop. In the disseminated varieties, daughter tubercles may form at the periphery, and in the confluent type the nodules which have undergone caseation, necrosis and liquefaction communicate through fistulous tracts.

2. *Sclerosing.* This form is characterized by excess fibrosis and is seen more frequently in older people.

3. *Atypical.* In this group are included rare types of lesions such as obliterating tuberculous mastitis and intraglandular cold abscess.

On section, the specimen may resemble chronic mastitis with greyish discoloration of the normally white breast tissue. Localized areas of caseation and cyst formation may be present. The microscopic appearance establishes the diagnosis. One should see tubercles with caseation, Langhans giant cells with peripheral nuclei, and epithelioid cells.

Smears, cultures and guinea pig inoculation may be taken but it is frequently difficult to find the bacilli especially in cases of sinus formation in which secondary infections by pyogenic organisms are superimposed. In only one-fourth of the 439 cases reviewed by Morgen was the organism found. The organism is also difficult to isolate in the pathologic sections.

*Diagnosis.* Most patients are in ap-

parent good health. The most frequent presenting symptom is a lump in the breast, which is usually painless. (This is present in approximately 70 per cent of the cases.) Pain is complained of initially in only about 8 per cent of the cases. Another presenting complaint may be a referable, persistent, discharging sinus after spontaneous rupture or surgical incision and drainage of what appeared to be a pyogenic breast infection with abscess formation. A discharging sinus is present in from 20 to 50 per cent of the lesions. Enlarged axillary nodes may be noted by the patient and are reported to be present in from one-half to two-thirds of the cases. The variable physical findings depend upon the stage of the disease and the type of the underlying pathological condition. A discrete, non-tender, circumscribed mass may be felt, resembling a benign tumor or a cyst. On the other hand, one may find a lump which is attached to the skin, with nipple retraction and with associated palpable non-suppurating axillary nodes. In this type we believe it is impossible to differentiate between carcinoma and tuberculosis clinically. Then again examination may reveal signs of acute inflammation with swelling, heat, redness, tenderness and possibly fluctuation suggesting abscess formation, or there may be signs of chronic breast inflammation with the overlying skin fixed, thickened, red and ulcerated or perforated by one or more discharging sinuses. In the latter, the condition may simulate a broken down gumma or actinomycosis of the breast.

To make the problem even more difficult, there may be associated tuberculosis and carcinoma in the same breast. Approximately twenty-six cases have been reported to date and our series includes two more. The condition is almost always unilateral. Frequently one can palpate enlarged axillary nodes, and sometimes supraclavicular and cervical nodes. If the nodes have broken down, sinuses will be present.

In the series of seven cases reported by Nicolson and Gillespie,<sup>2</sup> the condition was

correctly diagnosed preoperatively in all the cases; however, in the various series in the literature, and especially in our own,

the body, such as the lungs, lymph nodes or skeletal system, the diagnosis should be suspected immediately.

FIG. 1.

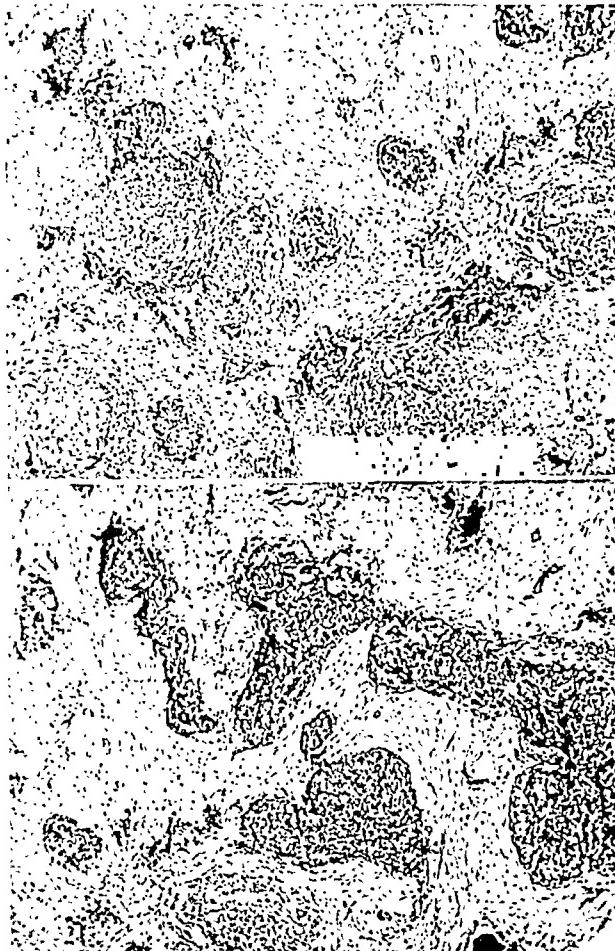


FIG. 2.

FIG. 1. Case 1. Combination of tuberculosis and carcinoma of breast. Section showing a number of tubercles interspersed with small nests of carcinoma cells; microphotograph  $\times 110$ .

FIG. 2. Case 1. Combination of tuberculosis and carcinoma of breast. Section showing nests of carcinoma cells in a fibrous connective tissue stroma. Note presence of a tubercle at bottom of field; microphotograph  $\times 110$ .

the preoperative diagnosis of tuberculosis of the breast was usually not made. The most frequent clinical diagnosis was carcinoma and unless a frozen section was performed at the time of the operation the patient might unnecessarily be subjected to the ordeal of a radical mastectomy when a simple mastectomy would have sufficed.

When sinuses are present or when tuberculosis is present in other parts of

In the study of material obtained by aspiration or from a sinus suspected of being tuberculosis, it is well to remember that a single report is not sufficient to rule out tuberculosis. Secondary infection by pyogenic organisms is frequent and the routine culture and smear will easily show these organisms at a glance, while the tubercle bacilli which stain with difficulty and are less numerous may be impossible to demonstrate by these methods in the

face of heavy secondary infection. For this reason a routine culture and smear reported negative for tuberculosis is not

microscopic study of tissue obtained by curetting or biopsy.

*B—In Patients without Sinus Formation:*

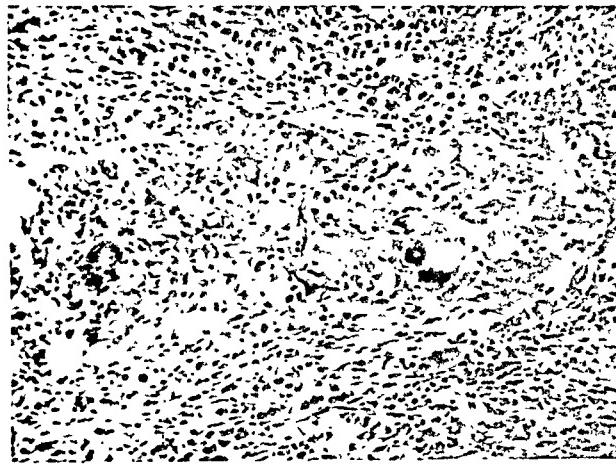


FIG. 3. Case II. Tuberculosis and carcinoma of breast. Section showing a nest of conglomerate tubercles surrounded by fields of medullary carcinoma; microphotograph  $\times 300$ .

conclusive in ruling out the condition, and guinea pig inoculation is therefore advisable in all cases. In one of our cases (Case IX) smears and cultures taken from discharging breast sinuses were reported as showing the presence of actinomycetes plus streptococcus anhæmolyticus and staphylococcus. We were preparing to present the case as one of actinomycosis of the breast when the guinea pig report proved the presence of acid-fast bacilli.

X-ray of the chest should also be done in all cases with suspicious breast lesions because 12 to 16 per cent of the cases of mammary tuberculosis have positive pulmonary tuberculosis.

*Differential Diagnosis—A—In Patients Having Discharging Sinuses:* (1) simple pyogenic mastitis; (2) degenerated gumma; (3) actinomycosis; (4) carcinoma. (1) In chronic pyogenic mastitis, pathological study of scrapings from sinuses should fail to show tuberculous granulation tissue. Heavy secondary infection may distort the typical pathological picture of tuberculosis. (2) Gummas are very rare. (3) actinomycosis, diagnosed by demonstration of the ray fungus in the discharge. (4) In carcinoma with sinus formation,

(1) Carcinoma—In the nodular type of tuberculosis there may be a painless mass, skin fixation and palpable axillary nodes. We believe this type to be indistinguishable, clinically, from carcinoma. In this connection Nicolson and Gillespie state that tuberculosis occurs in younger people and the tumor increases in size more rapidly. Nipple retraction is more frequent in carcinoma and nipple discharge is more frequent in tuberculosis. The discharge is usually purulent in tuberculosis, but in carcinoma it is serous or sanguineous. Sclerosing tuberculous mastitis may so closely resemble carcinoma that even on gross section one could not distinguish between them. (2) Benign fibro-epithelial tumors are freely moveable, circumscribed and have no skin fixation or axillary node involvement. However, in one of our cases with these features and a preoperative diagnosis of fibro-adenoma, the pathological report after excision was carcinoma as well as tuberculosis. (3) Chronic cystic mastitis—usually bilateral, of longer duration, pain more frequent and usually more severe just before onset of menses. The skin is involved frequently in tuberculosis but not in cystic mastitis. Nipple retraction

is more frequent in tuberculosis. Aspiration and study of the fluid from the cyst, including guinea pig inoculation, should be done in doubtful cases. Axillary nodes may be present in both conditions and are, therefore, of no differential importance. Rarely cystic may so closely simulate tuberculous mastitis that a biopsy is needed to make the diagnosis. (4) Gummas are rare. A negative Wassermann test is not able to rule it out completely. A therapeutic test and provocative reaction are helpful. (5) Plasma cell mastitis is differentiated from carcinoma and from tuberculosis by the acute onset and by rapid response in two to three weeks following a small amount of radiation therapy. (6) Traumatic fat necrosis may resemble carcinoma or tuberculosis. A history of injury preceding the onset of symptoms should make one suspect this condition.

*Prognosis.* In primary cases in which the patients are properly treated the prognosis is good. Untreated, the condition may spread to the thorax and its viscera or to other organs and lead to a fatal outcome. Lee and Floyd<sup>7</sup> state that there are no proven cases of breast tuberculosis which have spontaneously recovered. In secondary cases the prognosis depends upon the primary focus and its activity and extent.

*Treatment.* Many forms of therapy have been used in the past including curettage, cauterization, aspiration, incision and drainage and injection of the sinus with various preparations. More recently, Berger and Mandelbaum<sup>6</sup> reported on the use of tuberculin inunction plus heliotherapy in one case and they believed that further trial of this type of therapy was justified.

The generally accepted treatment of choice is excision. Occasionally, small, localized lesions may be removed with an adequate amount of normal breast tissue but usually simple mastectomy is necessary. Routine pre- and postoperative radiation therapy is advocated by some; others believe that postoperative

radiation should be given only when accompanying axillary lymph nodes are involved. A smaller group of surgeons advise radical mastectomy when the axillary lymph nodes are affected.

In non-surgical treatment or in the treatment of recurrences, roentgen therapy is recommended.

#### CASE REPORTS

**CASE I.** Patient, M. B., No. 30969, a forty-eight year old female, was admitted with a history of pain in the right breast of a sharp, shooting character and a mass of one month's duration. There were occasional shooting pains radiating to the right axilla. The patient was married and had one child who was living and well. It was not known whether the patient nursed the child or if there was any history of tuberculosis.

Examination revealed a walnut-sized mass in the upper, inner quadrant of the right breast. It was firm, not tender. It was not attached to the skin but was embedded in breast tissue. The nipple was normal, no orange skin. No palpable glands were present.

A preoperative diagnosis of fibro-adenoma of the breast was made. At operation the mass and surrounding normal breast tissue were excised. The postoperative diagnosis was the same as the preoperative diagnosis. The patient was discharged on the third postoperative day.

Pathological report, No. 6906, gross—1 cm. translucent tissue. Microscopic—adenocarcinoma arising in the ducts. Other sections showed conglomerate tubercles and giant and epithelioid cells. Diagnosis: carcinoma and tuberculosis of the breast.

The patient died seven years later with metastases to the supraclavicular area and to the thyroid.

**CASE II.** Patient, J. M., No. 13772, a thirty-three year old female, was admitted with a history of a mass in the left breast of one year's duration; there was no pain but progressive enlargement of the mass. The patient had ten children. Twelve years previous to admission a newborn infant died and lactation was suppressed. A small nodule appeared but soon disappeared. Five years prior to admission the patient was struck on the left breast by a ball. A mass developed but it disappeared.

Examination revealed a firm mass, the size of an egg, irregular in shape in the upper inner quadrant of the breast. No axillary nodes were palpable. The urine report was negative. Culture from the necrotic tumor area showed no organisms. Serology was negative.

A preoperative diagnosis of carcinoma was made and a radical mastectomy was performed. The patient was discharged on the eighteenth postoperative day.

Pathological report, S-1965, C-5348, (1) medullary carcinoma, (2) tuberculosis of the breast, (3) tuberculous involvement of axillary glands and of glands in the region of the internal mammary artery.

*Comment.* Approximately twenty-six proven cases of co-existing tuberculosis and carcinoma of the breast had been reported in the literature prior to this study.

CASE III. Patient, A. W., No. 169369, a thirty-eight year old female, was admitted with a history of a "lump" in the left breast with very little pain of two months' duration. There was no weight loss. The patient was married for seventeen years and had seven children, the youngest of which was fourteen months old. She had nursed the first four children for the full time but did not nurse the last three. There had been no miscarriages. Menstruation lasted six to seven days, every six to seven weeks, with no pain.

Examination revealed an 8 cm. irregular, hard mass with a sharp, hard edge in the upper, inner and outer quadrant of the left breast. It was well encapsulated under the areola and attached to the skin but not to the pectoral muscle. The nipple was slightly retracted. There were a few soft, axillary glands. The urine was negative. A blood count had not been done. X-ray of the chest was negative. No pulmonary pathological condition was demonstrated clinically.

A preoperative diagnosis of carcinoma of the breast was made and a radical mastectomy was performed. The postoperative diagnosis was "probable carcinoma of the breast." The patient's postoperative course was good and she was discharged on the tenth day.

Pathological report, S-2883, cyst, 8 cm. in diameter, lined by a thick layer of granulation tissue and filled with creamy pus. The pectoral

muscles were not involved. The axillary nodes had numerous yellow foci. Sections showed tuberculous granulation tissue lining the wall of the cyst with some tubercles and giant cells. Occasionally, there was an atypical overgrowth of the glandular elements. Diagnosis: tuberculosis of the breast.

CASE IV: Patient, I. De Z., No. 12979, a twenty-seven year old female was admitted with the history that a bilateral mastectomy had been performed at another hospital one and half years previously. The pathological report was intracanalicular fibro-adenoma of the breast, bilateral, no tuberculosis or malignancy. At this time the patient complained of an ache in the scar of the left breast area with the development of a "lump" in the outer portion of the scar of three weeks' duration.

Examination revealed a small painful, tender area in the left mastectomy scar. The right mastectomy scar was well healed. General examination was negative. Clinical diagnosis was that of abscess or cyst formation in left mastectomy scar.

A preoperative diagnosis of recurrent cystadenoma of the left breast was made. At operation an elliptical incision was made excising the small cystic mass from the site of the previous mastectomy scar.

Pathological report, S-1743, small cystic cavity in an old, well healed scar; lining of soft, friable tissue. Microscopic—cavity lined with a layer of tuberculous granulation tissue. Diagnosis: tuberculosis in scar of a previous mastectomy.

CASE V. Patient, H. W., No. 13752, a twenty-nine year old female was admitted with a history of enlargement of the right breast of four weeks' duration with fever and fluctuation of one week's duration. The onset was like that of an acute infection. An incision and drainage had been performed outside of the hospital. Following this procedure the breast became enlarged and glands appeared in the axilla. The patient's temperature rose to 104°F.

A preoperative diagnosis of abscess of the right breast was made. At operation the old incision was spread apart, a large amount of pus was evacuated and a section of tissue was removed for pathologic study. A counter incision was made and gauze packing was inserted. On the first postoperative day the

patient's temperature rose to 104.8°F. A blood culture was negative. The temperature came down by lysis. The patient was discharged on the seventh postoperative day.

Pathological report, S-1994, fatty tissue and lymph glands from the breast; microscopic—acute and chronic inflammation and tuberculous mastitis; epithelioid and giant cells. C-5994, section of granulation tissue—tuberculous mastitis.

The patient was treated with ultra-violet for several months and then multiple sinuses developed which were similarly treated. We have been unable to locate the patient for follow-up study.

CASE VI. Patient, I. S., No. 32915, a forty-five years old female was admitted with the following history: She had been admitted on November 11, 1930, with a preoperative diagnosis of a lipoma of the right breast. Operation was performed under local anesthesia and a 3 cm. cyst was excised. The patient was discharged on the following day. Pathological report No. 6690 revealed an inflammatory cyst of the breast; there was no evidence of tuberculosis.

On November 21, 1930, the patient was readmitted because of non-healing of the wound. X-ray of the chest showed no bone disorder but old fibrotic lesions in the apices and first interspace on the left side. The wound was irrigated and strapped. The patient was discharged on December 4, 1930.

On December 15, 1930, the patient was readmitted because the wound was not healing. The wound was resutured and drained. By December 26th the wound still had not healed. On January 13, 1931, a preoperative diagnosis of non-healing right breast wound was made. At operation the sinus was probed and opened wide. This ran to the cartilage of the eighth rib where a caseous area the size of a dime was found. This was curetted. The wound was sutured and drained. Pathological report, No. 6954, sinus wall—tuberculosis. The patient was discharged on February 25, 1931.

On May 11, 1931, the patient was readmitted for a fracture of the shaft of the right humerus. Examination of the breast at that time revealed that there was still a granulating sinus in the right breast region. The fracture of the arm healed; good callous formation took place. The patient was discharged on July 28, 1931.

On October 26, 1931, the wound has finally

healed after alpine light therapy two to three times a week. A four year follow-up revealed the wound to be well healed; there has been no recurrence.

CASE VII. Patient, E. R., No. 84305, a thirty-six year old female was admitted on January 3, 1935, with a history of a mass in the left breast of four months' duration. It was painless and non-tender. There was no history of tuberculosis in the family and no pulmonary symptoms. The patient had two children.

Examination revealed a firm mass, plum size in the lower inner quadrant of the left breast. It was freely moveable within the breast but attached to the underlying seventh and eighth ribs at the chondrosternal articulation. X-ray of the lungs was negative. Urine and blood serology was negative. Blood count was as follows: hemoglobin 70, red blood count, 4,480,000, white blood count, 8,700, polymorphonuclears, 58, eosinophiles, 5, lymphocytes, 32, mononuclears, 5.

A preoperative diagnosis of osteochondroma was made. At operation January 5th the mass was found to be an abscess cavity which was excised after it had been inadvertently opened. Creamy white pus exuded, which on culture was sterile; guinea pig inoculation was positive for tuberculosis.

Pathological report, No. 13113, cyst; microscopic—granulation tissue in which were numerous tubercles.

The patient was discharged on the ninth postoperative day with the wound healing.

The patient was readmitted on September 27, 1937, for the repair of a ventral hernia which was at the site of the cesarean sections performed five and six years previously. There was also present a draining sinus of the left breast of eight weeks' duration. The patient had been treated with x-ray therapy. Two years and seven months after the operation the wound broke down. Examination revealed a sinus attached by fibrous tissue to the deep fascia or to the ribs.

On September 28th, the ventral hernia was repaired and the breast sinus curetted. The sinus was found to be  $\frac{3}{4}$  of an inch deep. The wall was curetted and iodoform packing inserted. The curettings were not sent to the laboratory. X-ray of the chest and ribs was negative. On January 13, 1938, the sinus was healed.

On July 8, 1940, the patient was readmitted because of kidney symptoms. She had frequency, nocturia and burning of eight months' duration. She had lost sixteen pounds in the past eight months. Urologic work-up revealed renal tuberculosis on the left side. This was confirmed by guinea pig inoculation.

The old breast scar was well healed; there had been no recurrence.

**CASE VIII.** Patient, J. G. W.,\* No. 83487, a twenty-three year old male was admitted on April 4, 1938, with a history of swelling of the right breast of five weeks' duration. It was painless until the day before admission. The patient had a past history of tuberculosis of the right knee for which a synovectomy and meniscectomy had been performed in June, 1934. The patient was readmitted to the hospital from April to December, 1935, during which time an arthrodesis of the right knee was performed. At a later date an incision and drainage was also done. The right lower extremity had to be amputated above the knee which was followed by a disarticulation at the hip. In June, 1936, the patient was readmitted for one day for dressing of the stump which had become infected. The patient became an artificial limb salesman.

Examination revealed a diffuse enlargement of the right breast which was slightly tender and fluctuant. The mass seemed to be attached to the fourth rib at the costosternal junction. Tenderness was also present when firm pressure was made on the subjacent rib. The nipple was not involved.

A preoperative diagnosis of tuberculous mastitis was made. Aspiration yielded pus tinged with blood which on examination revealed many polymorphonuclears and moderate lymphocytes. The culture was sterile after forty-eight hours. Guinea pig inoculation was positive for tuberculosis. Tuberlin test was positive 1-100 to 1-10,000. The sedimentation rate was 17 mm. The blood count was normal. X-rays of the lungs and ribs were negative.

The patient was discharged to a convalescent home for conservative therapy which consisted of repeated aspirations, ultra-violet and infrared therapy. The patient remained at the home from April 19, 1938 to October 14, 1938. On discharge the condition appeared ap-

parently arrested. There was no external evidence of disease and x-rays of the ribs showed no bone involvement.

The patient was readmitted to the hospital on May 25, 1940 because of tuberculous epididymitis and seminal vesiculitis. Urine examination and guinea pig inoculation were positive for tuberculosis. A left epididymo-orchectomy was performed. Pathological report revealed tuberculosis.

Physical examination of the right breast at that time revealed no apparent disorder. The patient was discharged on June 15, 1940.

**CASE IX.** Patient, A. F., No. 91352, a forty year old female, was admitted with a history of heaviness of the left breast of five months' duration, and draining sinuses in the left axilla of one year's duration. Fifteen months prior to admission (in June 1940) the patient had a painful red swelling in the left axilla but no discharge. Three months later an incision and drainage was performed in the out-patient department of another hospital. The wound healed after seven months of home treatment. In April, 1941, the discharge reappeared in the left axillary wound. An incision and drainage was performed by a local medical doctor under novocaine anesthesia. The wound did not heal after several months of treatment and the patient came to the out-patient department of this hospital and was admitted for treatment on August 28, 1941.

The patient was born in Puerto Rico and had been in this country for fifteen years. She was married and had two children, ten and seven years of age, bottle fed.

Examination revealed the left breast to be thick and indurated. There were discharging sinuses in the left axilla and healed scars in the left cervical region. Sedimentation rate was 63 mm. Blood and urine examinations were normal. X-ray of the chest was negative. Tuberulin test was positive, 1-10,000. Smears made from the pus on August 30, 1941, revealed no tubercle bacilli. Guinea pig inoculation was done. On September 5th smear and culture from the wound revealed streptococci in twenty-four hours, and actinomycoses in one week. There was also polymorphonuclears, gram-positive cocci and filaments. On September 20th an incision, drainage and biopsy of the sinus bearing area was performed revealing granulomatous infiltration of the breast. Micro-

\*The authors are grateful to Dr. Leo Mayer for permission to use this case.

scopic findings were reported consistent with the diagnosis of actinomycosis. Smear showed gram-positive filaments. Culture showed gram-positive and negative aerobic bacilli; staphylococcus and streptococcus anhaemolyticus; actinomycosis at twelve days. The pathological report of biopsy revealed chronically inflamed granulation tissue, giant cells and areas of necrosis. There were granulomatous nodules with purulent centers.

Postoperatively there was profuse, purulent discharge from the sinuses in the indurated left breast. The patient was given ultra-violet treatment for eight days, from September 5th to the 13th. On September 20th sodium iodide was begun but stopped on September 26th when the diagnosis of actinomycosis was made; 5 Gm. of sulfathiazole powder suspended in peroxide were instilled into the wound daily for twelve days. On September 30th, x-ray therapy was started.

The patient had been treated for actinomycosis on the basis of cultures reported on September 5th and September 20th and biopsy report of September 20th. However, on October 10th the guinea pig which had been inoculated with the pus taken from the discharging sinus on August 8th was autopsied and found to have tuberculosis.

The follow-up study revealed that the patient had been receiving cold quartz and heliotherapy to the left breast and when she was last seen on April 27, 1942, there was a granulating area 4 by 4 mm. in the left breast.

#### SUMMARY

1. Nine cases of tuberculosis of the breast have been presented including two cases with co-existing carcinoma.

2. The need for guinea pig inoculation in addition to the usual bacteriologic study of chronic discharging breast sinuses is suggested.

3. For the proper surgical management of all suspicious breast lesions, we believe that the use of the frozen section is essential.

4. In only two of our nine cases was the diagnosis suspected preoperatively; one of these patients had chronic discharging sinuses and one had previous joint tuberculosis.

#### CONCLUSION

In our experience with tuberculosis of the breast, we have been unable to make a clinical diagnosis with any reasonable degree of frequency.

The authors gratefully acknowledge the assistance rendered by Dr. Henry L. Jaffe and Dr. Louis Lichtenstein of the Pathology Department of the Hospital for Joint Diseases.

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# CHOLECYSTITIS\*

## THE ADVANTAGES OF OPERATIVE TREATMENT IN DEFINITE UNMISTAKABLE DISEASE

FRANCIS X. TIMONEY, M.D.

Visiting Surgeon, St. Vincent's Hospital

NEW YORK, NEW YORK

SURGICAL conditions of frequent occurrence warrant periodical reviews. Cholecystitis is an example regularly encountered by general surgeons in all hospitals. Practical values require that such a review contain only recent cases. To consider results of ten years ago together with those of today would not make for a fair comparison. This is so because of the recent improvements in anesthesia, increased knowledge of nutrition, fluid balance and the use of chemotherapy. Accordingly only a recent three-year review will be considered. This period extends from June, 1940, to June, 1943. These cases are from one surgical division representing approximately one-half of the patients with gallbladder disease who entered St. Vincent's Hospital in that given time. One hundred fifty-one cases comprise the group. These patients were subjected to surgery by a rotating group of nine operators.

It has long been our policy to be most rigid in the selection of patients for operation. We have tried as far as possible to operate upon patients with definite unmistakable disease. This is borne out by the fact that 114, or more than 75 per cent, of the patients had gallstones. This is in strict accordance with accepted modern surgical consideration of cholecystitis.<sup>1-4</sup> In 1931, Stuart and Timoney,<sup>5</sup> in an unpublished report, showed the following: In non-calculus cholecystitis the rate of cure was only 42 per cent; in cases with stones the rate of cure rose to 77 per cent. They further showed that patients with gallstones obtained good results following either cholecystec-

tomy or cholecystostomy. This indicated that satisfactory results depended more upon positive disease than upon the type of operation performed.

Cole<sup>6</sup> estimates the incidence of cholelithiasis in most clinics as hovering around 50 per cent. He cites Heyd reporting 59 per cent and Deaver 50 per cent. Cole also states that 8 per cent of all cases of cholecystitis in hospitals are acute. In our present series, thirty-five or 23.17 per cent were either acute or subacute. This increase over the low figure of 8 per cent is largely due to an active ambulance service in a hospital where many acute and emergency cases are admitted. Operations performed on patients with acute cholecystitis is an added assurance of dealing with definite and unmistakable disease. We agree with Gray<sup>4</sup> that the history of an acute attack alone is not sufficient reason for cholecystectomy. Definite pathological change must be present. We firmly believe that operation should be performed only for gallstones or proved disease. Cholecystectomy performed in border-line cases or where disease is non-existent, carries an endless chain of distressing digestive symptoms. This is referred to as post-cholecystectomy syndrome or reflex biliary dyskinesia. The treatment of this symptom complex is unsatisfactory, attended with only limited results. From their studies, Goldman and Bell<sup>7</sup> state that "the removal of the stoneless gallbladder may not only be without benefit but may be harmful."

As will be shown it is a disease of late middle life. The increased life expectancy, the increased age of our population and the

\* From the First Surgical Division, St. Vincent's Hospital, New York City, Dr. George R. Stuart, Director.

increased accuracy of diagnosis may reasonably lead us to expect to encounter more and more cases. In their comprehensive review of gallbladder surgery, Brooks and Wyatt<sup>8</sup> state that improvement in treatment and the lessening of mortality in gallbladder disease should be more generally recognized. As a measure toward increasing life expectancy during the past fifty years, it ranks with the reduction of infant mortality and the improved treatment of tuberculosis. In the later years of their series these authors had performed 245 consecutive cholecystectomies without a death—a splendid record. In a study of carcinoma of the gallbladder Lam<sup>9</sup> cites Graham, who stated that the incidence of cancer developing in gallbladders with stones would exceed by far the 1 to 3 per cent usual operative mortality for gallbladders with stones. Lam also emphasizes the comparatively hopeless prognosis in carcinoma of the gallbladder. Lichtenstein and Tannenbaum<sup>10</sup> in carcinoma of the gallbladder report the incidence of stone as being 69 per cent of their seventy-five studied cases. From these studies one might reasonably conclude that a stone in the gallbladder is a predisposing factor in the production of cancer in this organ. This would further increase the value of the operative treatment of cholelithiasis.

**Sex.** Of the 151 cases studied, ninety were female and sixty-one male. This 3 to 2 ratio is considerably different from the usually given 3 or 4 to 1 ratio.

**Age.** Many ages were represented as shown in the following table:

TABLE I  
151 CASES OF CHOLECYSTITIS

Age Group . . . . .	20-30 years	30-40 years	40-50 years	50-60 years	60-70 years	70- years
-No. of patients..	11	40	38	37	21	4
Percentage.....	7.21	26.4	25.1	24.5	13.9	2.6

**Diagnosis.** A reasonably high degree of diagnostic accuracy was obtained. The

diagnosis was correct in 144 or all but seven cases. This can be attributed to certain factors, viz., roentgenographic evidence of stone, repeated non-filling of the gallbladder during cholecystography, or the history with symptoms and definite physical signs of an acute attack. A wrong or inaccurate diagnosis was obtained in the seven cases as follows:

1. Undetermined. Various possibilities were considered before operation. At exploration, gall-stones were encountered.

2. Diseased gallbladder removed coincidental to gastrectomy for gastric ulcer.

3. Gastric ulcer. Gallstones were found and the gallbladder removed. Deformity of stomach was caused by an adhesion.

4. Carcinoma of gallbladder. Patient, female, sixty-six years of age, had stones of long-standing, loss of weight, leucocytosis. May also have had tabes dorsalis. Gallbladder was removed and a widely dilated common duct drained. Outcome was fatal.

5. Undetermined. Preoperative x-ray showed a calcified mass which appeared to be outside the gallbladder. The nature of this calcified mass was undetermined. At operation a gallstone in the very redundant fundus of the gallbladder was encountered.

6. Acute appendicitis.

7. Acute appendicitis.

In cases two and four, gallstones were recognized on roentgen films but were not considered causative of the symptoms noted. Thus, these two cases are listed among the errors of diagnosis because operation was not primarily performed for the removal of gallstones.

**Treatment.** The 151 patients were treated as follows:

Cholecystectomy (alone).....	125
Cholecystectomy with choledochostomy.....	9
Cholecystectomy with gastrectomy.....	2
Cholecystectomy with gastroenterostomy.....	1
Cholecystectomies.....	137
Cholecystostomies.....	14
Total number of cases.....	151

Cholecystectomy was the operation of choice in more than 90 per cent of cases. Of the fourteen patients subjected to cholecystostomy, there were no deaths. Eight cases were acute and six were chronic. Eleven of the gallbladders drained contained stones. Three were stoneless. The number of cases of drainage of the gallbladder is so small as to allow no special consideration. We also are of the generally accepted opinion that cholecystectomy is the operation of choice.

Nine, or 6 per cent, of our patients required drainage of the common duct. Enthusiasm for exploration of the common duct should be tempered and guided by indications present. The outstanding indications for common duct drainage are palpation of stones, history of jaundice, multiple small stones in the gallbladder with a dilated cystic duct, dilatation of the common duct and enlargement of the head of the pancreas. Goldman and Bell<sup>7</sup> drained the common duct in 20 per cent of all cases, and of these found stones in only 11 per cent. They state that as a result of this enthusiasm for draining the common duct, they have encountered many cases with ductal stricture and biliary fistulas. We agree that in cases of common duct drainage cholangiograms should be taken at the time of operation. Thus an occasional stone in the biliary tree that might be overlooked at operation may be found.

The operation of cholecystectomy is not without risk. Good results are more attributable to the skill of the operator than to any other factor. This competence of the surgeon is stressed by Strelinger<sup>11</sup> and by Brooks and Wyatt.<sup>8</sup> They state that the skill of the operator counts more than knowledge of water balance, carbohydrate reserve, etc.

Complications were frequent, occurring in twenty-eight or 18.5 per cent of cases.

#### *Complications:*

Postoperative pneumonia.....	8
Pulmonary atelectasis.....	9
Pulmonary atelectasis with massive collapse and lues.....	1 (fatal)

Postoperative bronchitis.....	2
Subphrenic abscess.....	1
Subphrenic abscess with secondary pyopneumothorax.....	1
Cardiac decompensation—postoperative autopsy.....	1 (fatal)
Femoral phlebitis with pulmonary embolism	
Generalized peritonitis. While sleeping the patient pulled the T-tube from the common duct seven days after operation. X-ray showed signs of subphrenic space abscess.....	1 (fatal)
Postoperative stenosis of common duct....	1 (fatal)
Biliary fistula.....	1
Incomplete intestinal obstruction.	

Total.....	28
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Of these complications at least twenty were pulmonary in origin. We believe that today the timely use of sulfonamide therapy would either prevent the occurrence or lessen the severity of many pulmonary complications. It might also be stated that the increasingly frequent use of the oblique subcostal and transverse incisions will further contribute to the reduction of pulmonary complications. In four instances complications contributed to fatalities. Russo,<sup>12</sup> in his gallbladder review, mentions cardiac, accidental and other factors in the cause of death.

*Results.* Of 151 cases reviewed there were six fatalities or a mortality of 4 per cent.

#### *Mortalities:*

1. Case No. 24014. A male, fifty-seven years old, had a cholecystectomy performed for cholelithiasis. Postoperative pulmonary atelectasis developed and no sulfonamides were given.
2. Case No. 24089. A male, seventy-one years old, had a cholecystectomy for cholelithiasis. He died of postoperative shock and bronchopneumonia.
3. Case No. 13450. A female, aged fifty-eight, underwent cholecystectomy for cholelithiasis. She died from pulmonary edema secondary to cardiac decompensation as proved by autopsy.
4. Case No. 32207. A male, aged forty-nine, underwent cholecystectomy and choledochostomy for cholelithiasis. Seven

days postoperatively, the T-tube was found outside the dressing. Death occurred sixteen days postoperatively, with signs of generalized peritonitis and x-ray evidences of a subphrenic abscess.

5. Case No. 20983. A female, forty-seven years old, at the primary operation had a cholecystectomy performed for chronic cholecystitis without stones. She developed postoperative stenosis of the common duct with biliary fistula. At the secondary operation, hepatico-duodenostomy was performed over a rubber tube. The patient passed the tube a few weeks after operation. At the third operation hepaticostomy was performed. The patient died of shock and exhaustion.

6. Case No. 11306. A female, aged forty-seven, had cholecystectomy and choledostomy for gallstones and marked dilatation of the common duct. She had lues and developed massive collapse of the right lung.

If we eliminate the two cases of primary choledochostomy with cholecystectomy, the mortality for chronic cholecystitis as such would be reduced to four cases or 2.6 per cent. Cardiac disease contributed to fatality in one case, accidental injury to the common duct in another case, and in the other two cases pulmonary atelectasis and shock together with bronchopneumonia.

#### SUMMARY

One hundred fifty-one cases of gallbladder disease are reviewed. These are the patients treated by the First Surgical Division Staff at St. Vincent's Hospital in a three-year period. The incidence of stone in the gallbladder was 75 per cent. The total operative mortality for all cases was 4 per cent. The operative mortality for chronic cholecystitis alone was 2.6 per cent.

#### CONCLUSIONS

Operations performed in the presence of definite unmistakable gallbladder disease give assurance of increased satisfactory results. This is accomplished by more strictly limiting the indications for operation. The presence of gallstones, or the history or presence of an acute attack, make reasonably certain the indications for operation. The operative mortality for definite unmistakable gallbladder disease can be kept to a reasonably low figure.

The author wishes to thank Dr. Gerald F. O'Brien for his help in compiling statistics.

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# CLOTHESPIN GRAFT OF THE SPINE FOR Spondylolisthesis AND LAMINAL DEFECTS\*

DAVID M. BOSWORTH, M.D.

Associate Attending Orthopedic Surgeon, St. Luke's Hospital

NEW YORK, NEW YORK

**B**ECAUSE of the difficulty in securing a satisfactorily high percentage of arthrodesis on attempting to repair laminal defects, bridge spondylolisthesis defects, or secure fusions to include more than one lumbar segment to the sacrum, improvement of graft technic was attempted. Fixation of tibial grafts to spinous processes with vitallium screws proved unsatisfactory. The screws worked loose, the grafts became displaced, and absorption of grafted material occurred. It was thought that if graft placement could be solidly maintained by the shape of the graft alone, without other fixation, results could be improved. At first an inclusion graft was tried, encircling the spinous processes of lumbar 4, lumbar 5 and sacral 1 and was satisfactory. Because of the structural weakness of the graft so cut, the clothespin (or "H") graft was devised.

This consisted of a graft with the ends notched out to receive spinous processes at either end of the fusion area. It is placed with the patient in flexion and the spinous processes separated. The patient then being extended, it is maintained firmly in position. Separation of the posterior elements was not only found to occur due to the leverage action of the graft but of the anterior elements as well. (Fig. 1.) Intervertebral foraminae of the graft area were definitely enlarged by the distraction. In cases of spondylolisthesis, apparent reduction of the body which had slipped was secured. The word "apparent" is used since actual replacement did not occur but a certain amount of derotation

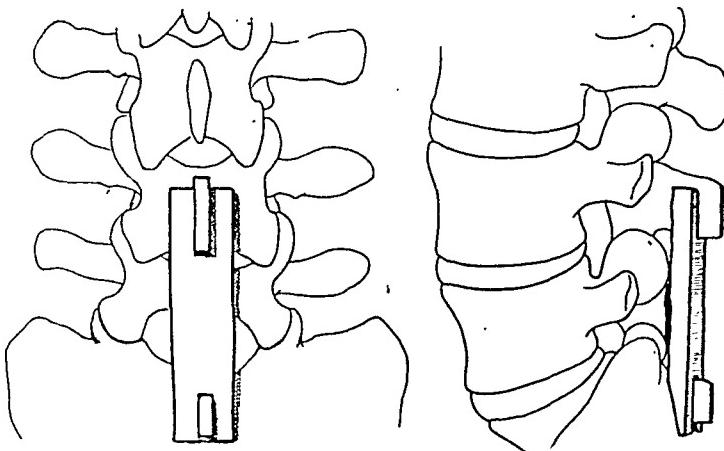
of the slipped body was obtained. Not only in theory but also in clinical experience decompression of nerve roots and immediate relief of pressure pain were normally secured. Tibial bone was used at first for graft substance but later massive iliac bone grafts have been used. The above fusions were reinforced with separate iliac strips in all but a few cases. (Fig. 2.) The rigidity of fixation resulting from the method of implantation of the main graft has held the extra iliac strips placed underneath in excellent contact with the posterior elements of the vertebrae. At least two other surgeons have used the procedure independently of us. The following will be an attempt to make an early analysis of certain results, difficulties and complications.

There have been seventy-seven such grafts done with but one mortality, this occurring seventy-two hours postoperatively. It was reported as delayed shock. During the operative procedure the dura was opened unintentionally on two occasions with small pin-prick openings. No symptomatic sequelae ensued. Mild shock was encountered in several instances and moderate shock on three occasions. There have been few recent cases of shock since we have routinely begun to use infusion of saline and glucose at the beginning of the operation. We would strongly urge that this always be done. In half of the cases two surgical teams were used with marked reduction in operative time. Such use of a second team will, of course, be impracticable where clothespins are fashioned of massive iliac grafts. As the surgeon ac-

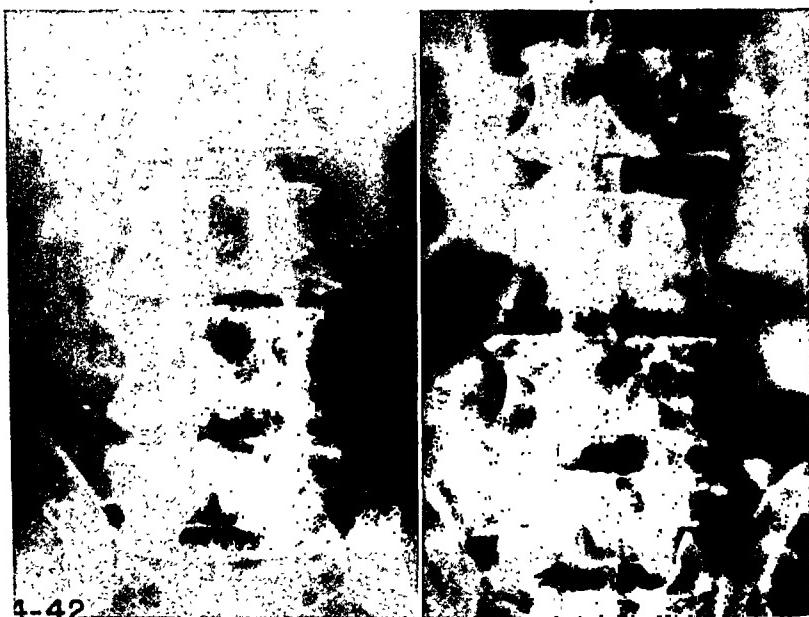
\* From the Orthopedic Service of St. Luke's Hospital, New York City. Read at the American Orthopedic Association, Cleveland, Ohio, June 7, 1943.

quires skill in the procedure he can dispense with the second team and still hold down his operative time. Trans-

tively. Stability of the graft at operation has routinely been good. As a matter of fact, the main grafts are so firmly wedged



A



B

FIG. 1. A and B, double clothespin graft has great strength, is firmly maintained in position when applied with the spine in flexion and then extended to normal, and provides a distracting force to separate intervertebral spaces as well as secure fusion. Note the opening of the third lumbar intervertebral space and separation of left fifth lumbar first sacral articular facet caused by long clothespin graft as shown in x-ray.

fusions planned in advance have been used on two occasions and plasma once. Fracture of one prong of a graft occurred during operation in one instance. In one other instance it occurred postoperatively. No fracture of the body of a graft has occurred either at operation or postopera-

in place that following extension of the patient they can be grasped and the patient's whole lower spine and pelvis shaken without any displacement of the graft. The strength of the spinous processes has always determined the mechanical stability of the grafted area.

There have been four postoperative infections. Two were due to hematoma, one due to silk suture in deep fascia and

tibia at the site of osteotomy occurred in four instances at seven, five, four and one months postoperatively. (Fig. 3.) This

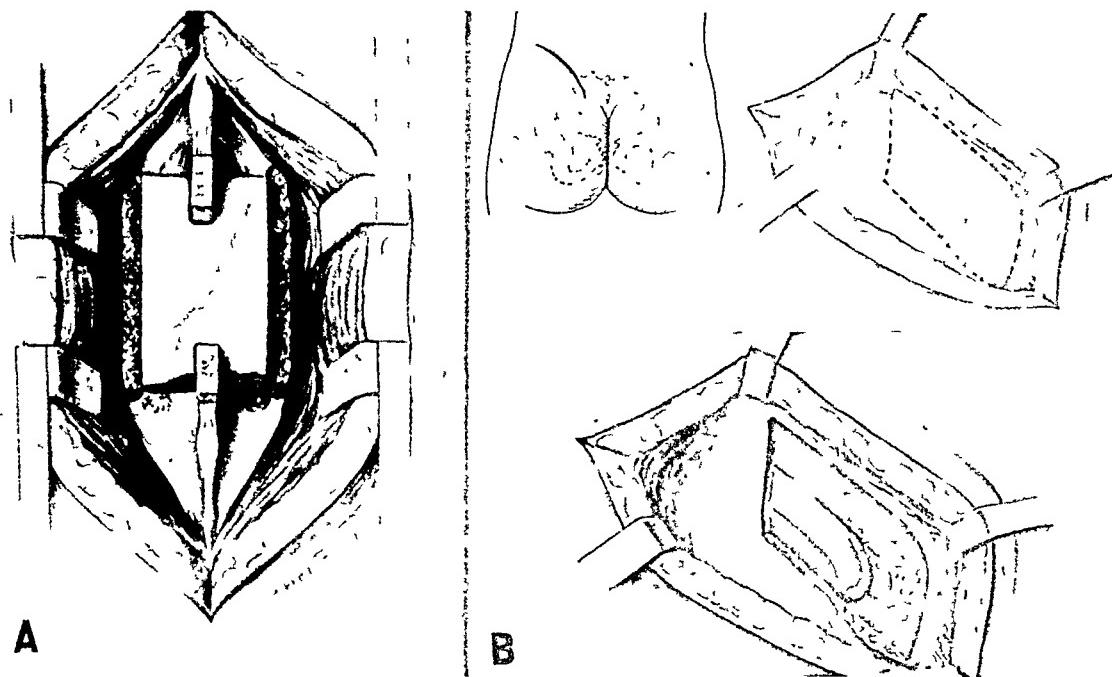


FIG. 2. A, double clothespin graft fashioned of massive iliac bone re-enforced with iliac strips. B, site of iliac incision and outline of massive iliac graft used for clothespin as well as cancellous iliac strip being removed.

one frankly operative. Two of these patients promptly lost their main grafts following the infection, but the others healed without further incident. There have been two grafts removed for aseptic necrosis, with negative cultures and primary healing followed the removal. One of these patients was re-grafted with iliac strips at the same operation at which the tibial graft was removed. Of the sixty cases in which tibial bone was used there have been four tibial hematomas, all at present healed. Among the fifty-four cases in which incisions were used for iliac bone there has been only one hematoma. Tourniquets were used in the first forty-six cases for removal of tibial grafts with the occurrence of thrombophlebitis of severe amount on two occasions and complete peroneal palsy on two occasions. All four patients recovered though with some amount of residual damage after thrombophlebitis. Spontaneous fracture of the

happened in three instances in spite of the prolonged use of crutches. All four fractures are satisfactorily united and enjoy complete weight-bearing at the present time without appreciable deformity. Replacement of the graft with a second clothespin has been done in one instance and with iliac strips in one other case. Two of the patients who lost their main tibial grafts are healed and solid due to the iliac strips laid along the lateral margins of the posterior vertebral elements at the original operation. In three instances the spinous process abutment on the sacrum has been dislodged by graft pressure at some time postoperatively as shown by x-ray findings. Two of these cases successfully united the graft to the sacrum despite the sliding displacement. A sulfa drug was implanted in a few instances but this practice discontinued. In addition to the above complications, there was one upper respiratory infection, one temporary

bladder and rectal retention, two mild postoperative cases of ileus, one pyelonephritis in a patient with a previous

The average time of operation was one hour and ten minutes, though it varied from forty to 150 minutes depending upon

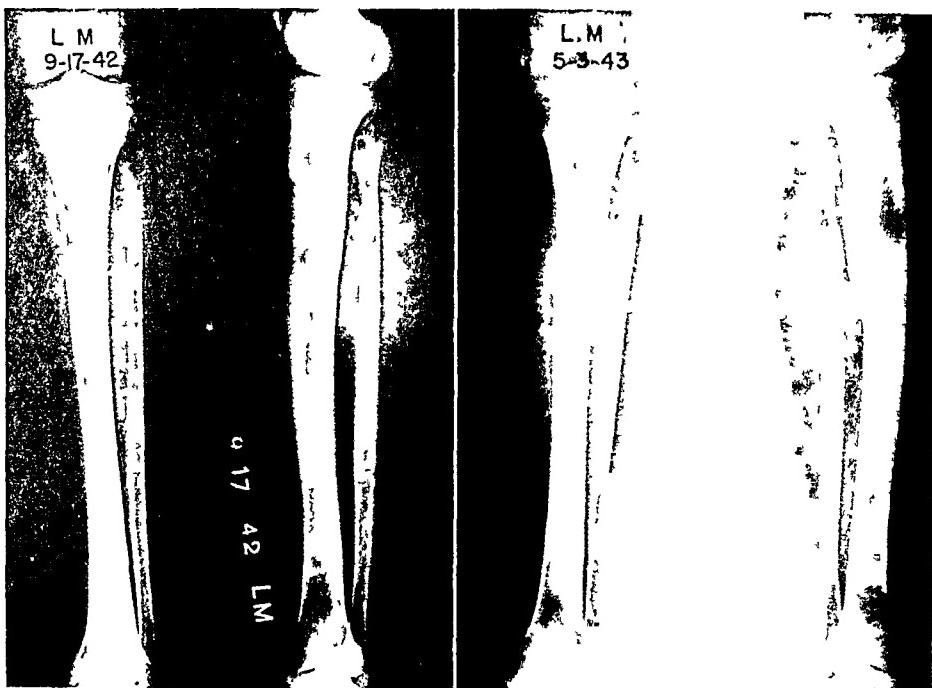


FIG 3 Pathological fracture of the tibia may occur as late as seven months postostectomy. The above occurred four months postoperatively, and was solidly united four months later. Such occurrences may occasionally have to be accepted where strength of tibial bone is needed for distraction. They can be avoided in other cases by using a massive double clothespin iliac graft.

prostatitis, an incident of appendectomy two days post-spinal fusion, and one patient became pregnant a month and a half following spinal fusion, a process which evidently did the graft situation no good.

Among the present series of patients submitted to the above procedure many other pathological lesions were found outside of the spinal area. Frequently present were obesity, cardiovascular disease, pelvic inflammatory conditions, prostatitis and hydrocele, gastrointestinal lesions, kidney disease or ptosis, chronic alcoholism, shell-shock, tuberculous glands, lues, hernias and anemia. These conditions frequently contributed to complications which arose.

The time of hospitalization varied from a low of twelve days to a high of four months. The usual time of hospitalization in the uncomplicated case was three weeks.

the difficulty of exploration for disc herniation. In one instance the operative time was 240 minutes when massive exploration and removal of a tumor was done by an associated neurosurgeon. In the early cases plaster jackets were applied immediately postoperatively. In all recent cases the fixation of the graft has been found to be so firm that the plaster support may be delayed for postoperative recovery. The jacket is now generally applied two and one-half weeks postoperatively. The patient with tibial osteotomy is allowed up on crutches at three weeks and continues on crutches for six weeks thereafter. Where the massive graft has been fashioned of iliac bone, the patient is made ambulatory immediately following cast application. An occasional patient has been kept recumbent up to a period of four months postoperatively. These are instances in which patients have had extensive spinal

work previously with the presence of pseudoarthroses, scarred operative sites, and extensive symptomatology.

grafts have been placed to include two segments above a previous fusion and in these instances the intervening spinous

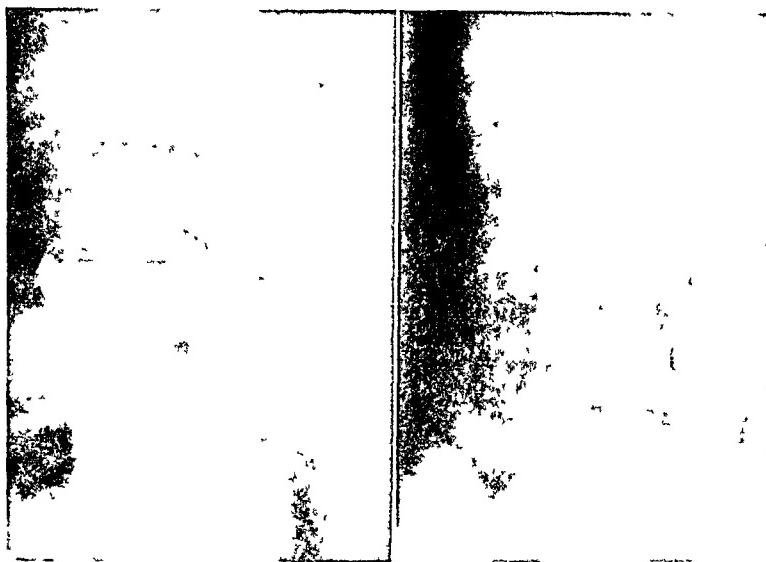


FIG. 4. The only sure proof of complete arthrodesis is the accurate superimposition of the fused segments in x-rays taken in flexion and extension, and in right and left lateral flexion. Note that the bodies of lumbar four to sacrum in the above x-rays accurately superimpose and that spinal motion begins at lumbar three. In the anteroposterior view due to rotation of the patient the graft itself may not accurately superimpose but in these cases the margins of the graft are parallel.

The type of graft used has included one inclusion graft, sixty-six double clothespin grafts, eight single clothespin grafts and two angulated strut grafts. The single clothespin grafts have been applied where fusion has previously been solidly secured but its extent upward is desired. These grafts then enclose the spinous process at the upper limit of the new fusion area desired and abut in a transverse groove cut in the previous fusion area. The double strut or angulated grafts have been used on two occasions for spondylolisthesis where there was complete associated spina bifida of all the sacral segments. These strut grafts are placed from the fourth lumbar spinous process to grooves cut transversely in the articular facet region of the first sacral segment. They are essentially single clothespin grafts placed in pairs. On three occasions double clothespin grafts have been used with a long slot in one end to include two or more spinous processes. In two instances single clothespin

process has been left in situ and passed through a hole cut in the clothespin graft. Sixty-three of the grafts have been fashioned from tibial bone and fourteen from massive sections of iliac bone. Where strength is desired and distraction of vertebral segments essential, tibial bone has been considered mandatory. Where only one intervertebral space is to be crossed and separation of the vertebrae is not essential, iliac bone is satisfactory for the main graft, more easily and safely obtained and more rapidly reossified. In all but ten instances the massive clothespin graft has been reinforced with additional strips of iliac bone. This has been done to secure a more rapid osteogenesis and more rapid fusion than would be obtained with the more densely sclerotic tibial strut. As will be shown later, results are more satisfactory when such strips are added to clothespin grafts. In order to satisfy ourselves on this point we ran a series of ten operations in which nothing but the

massive tibial clothespin graft was used. Though the percentage of final union in these cases was almost as good as in the whole series, the length of time to secure solid arthrodesis was much greater.

The area grafted varied considerably. There were thirteen cases with fusion from lumbar 3 to sacrum, forty-six from lumbar 4 to sacrum, and seven from lumbar 5 to sacrum. Single instances of arthrodesis of individual spaces or combination of spaces between lumbar 2 and sacrum were numerous. The basic conditions for which operation was performed were:

	No. of Cases
Spondylolisthesis.....	11
Posterior herniation of the intervertebral disc...	32
Laceration of the intervertebral disc without posterior protrusion (included among these are two probable cases of tuberculosis).....	8
Lumbosacral strain (associated Schmorl's nodes and dural adhesions included).....	20
Spinal cord tumor (neurosurgical associate operating).....	1
Old extensive laminectomy defects.....	3
Pseudarthrosis of previous spine fusion.....	2

Among the cases of posterior herniation of the intervertebral disc there were twenty-two with typical coiled-up nuclear material, eight with so-called organized chondromatous masses of unquestionable origin, and two with calcified herniated material. One of these two calcified discs included a patient with a calcific mass the size of a small marble directly under a nerve root, pressing it against the adjacent articular facet surface. The other was a calcified chondromatous mass. It is interesting to note that preoperatively eleven other cases were diagnosed as posterior herniation of the intervertebral disc when no definite disc mass could be found. Thus our percentage of absolutely accurate preoperative diagnosis of disc herniation is 66½ per cent correct in this series. As the series advanced the accuracy of diagnosis was noted to have improved.

Laminectomies were associated or antedated the clothespin graft fusion as follows: There were sixteen fresh (hemi or total) laminectomies of a vertebral seg-

ment accompanying the spine fusion. Most of these occurred among the first nineteen patients. There were three pre-existing old laminectomies associated with the pathology and symptomatology for which the present fusion operation was done. In twenty-five instances the lower or upper margin of a laminal arch was slightly rongeured to further the exploration for suspected herniation of intervertebral disc. Among the eleven cases of spondylolisthesis included in this series, eight had such extensive posterior displacement of the fifth laminal arch that a straight clothespin graft could not be laid without entire removal of this loose vertebral fragment. Four trisacral fusions for low back symptomatology had previously been performed, were found solid, and were added to. In addition there were two old extensive fusions with pseudarthroses upon which we implanted new tibial clothespin grafts reinforced with iliac bone. The repair of these patients and those with old laminectomy defects were difficult.

#### RESULTS

Fifty-five patients were operated upon before January, 1943. Since casts are not removed for five months postoperatively the question of solidity could not be determined later than that date. Our result statistics are therefore limited to these fifty-five cases.

Though we believe that clinical estimation of solidity of spinal fusion is unsatisfactory, the records show an estimated forty-nine cases (89 per cent) solid. One patient is being treated elsewhere. Four cases were clinical failures. We believe the only accurate method of determining solid spinal fusion is by flexion and extension x-rays. When such x-rays are superimposed and no motion whatever is shown we believe that solid ankylosis can be granted. (Fig. 4.) Superimposed right and left lateral flexion x-rays are an additional safeguard; forty-one of the cases have been checked with these motion x-rays;

thirty-three of them (83.3 per cent) are completely solid, the x-rays accurately superimpose, and no motion can be demonstrated. In six (14.6 per cent) there is motion demonstrable and failure of synostosis is therefore accepted as present. Two cases (4.9 per cent) almost superimpose in the flexion and extension views and are probably solid, the slight change being accounted for by rotation of the patient in taking the x-rays. If these were included, the patients with solid union would be 88 per cent of the series.

There were eleven instances of spondylolisthesis. One is too recent to report. Of the other ten, nine were of lumbar 5 and one of the fourth lumbar; eight are proved solid (80 per cent) by x-rays as denoted above. One case has questionable slight motion on superimposed lateral x-rays. All of the patients have complete stability and relief of preoperative symptomatology except for one proven failure.

Of the entire series all patients had entire clinical relief except four who were partially relieved and four unrelieved. It will be noted that two of the six patients with pseudarthroses have partial relief of their preoperative symptomatology. The definite known failures included two cases of posterior herniation of the intervertebral disc, one of lumbosacral strain,

one of spondylolisthesis, one old laminectomy defect and one old long multiple chip graft fusion with pseudarthroses throughout.

The series was analyzed in an attempt to determine the cause of failure. Among the six patients with pseudarthroses there were two in whom no extra bone outside the massive tibial graft was used, two who avulsed a small insecure first sacral spinous process, and two in whom no known cause of failure could be determined.

#### CONCLUSIONS

1. Where the stability and strength of tibial bone is not essential, the massive graft may be made of iliac bone to avoid occasional postoperative hematoma and infection of the tibial wound and the possibility of tibial fracture which exists for several months.
2. Infusion with glucose and saline should accompany, not follow, the operative procedure. Addition of transfusion at operation is now routine.
3. Grafts should always be reinforced with iliac strips.
4. For accurate estimation of spinal fusion x-rays in flexion and extension and right and left lateral flexion must superimpose.



# CONIZATION AND EARLY DIAGNOSIS OF CARCINOMA OF THE CERVIX\*

JOSEF J. HABER, M.D.

Chief Surgical Resident, Charleston General Hospital

CHARLESTON, WEST VIRGINIA

CARCINOMA of the cervix is the most common malignant lesion in the female. Twenty-seven to 30 per cent (Martzloff, Welch, and Orth) of all carcinomas in the female are uterine carcinomas of which 80 to 97 per cent (Koblanck, Backer, Blumenfeld) originate in the cervix. Therefore, we understand the great attention paid to the problems of diagnosis and treatment of this particular type of carcinoma. The early diagnosis of the beginning carcinomatous lesion of the cervix is absolutely essential for its successful treatment.

The tragedy of cervical carcinoma lies in the fact that the patient is frequently not seen until the malignancy is already far advanced. It is usually only in the advanced stages of carcinoma that definite symptoms are manifest, i.e., a bloody vaginal discharge and a history of hemorrhage on contact, such as that following vaginal examination or coitus. Pain is a late symptom and usually occurs after the cancer has already spread to the peritoneum and to the pelvic connective tissue which has a rich nerve supply. As a rule, few if any subjective symptoms are present during the early stage of this disease.

There are probably two reasons why early carcinoma of the cervix is discovered late: (1) The patient is not likely to seek medical advice unless symptoms are present. (2) The examining physician may overlook early malignancy or mistake it for a benign lesion.

The most certain way of diagnosing early carcinoma of the cervix is by biopsy. There are various accepted diagnostic

procedures but none of them are completely satisfactory. The positive Schiller test is not absolute proof of malignancy. According to Meyer, the correct diagnosis in 60 per cent of cases of carcinoma of the cervix would be missed by this test. Martzloff points out that the overwhelming majority of unstained areas shows no histological evidence of beginning cancer. Schiller, himself, states that his test is of no value at all in differentiating ulcerating carcinoma and erosion, and suggests biopsy in cervical lesions.

In an experimental check-up for cancer made by McFarlane, Fetterman and Sturgis on 1,000 supposedly well women, thirty years of age and over, 4 malignancies of the uterus and 357 benign lesions of the cervix were found by performing biopsies. Schmitz reports fifteen silent carcinomas that were discovered accidentally on histological examination of cervical tissue following amputation of the cervix for extensive cervicitis, in a series of cases of primary carcinoma of the cervix observed between the years 1915 to 1931.

In a microscopic study of cervical tissue from 669 cervices, which did not show any signs of carcinoma on gross examination and were treated for chronic inflammatory lesions, Smith discovered sixteen carcinomas of the cervix (2.39 per cent) by routine microscopic examination of the removed tissue.

Schmitz reports a 100 per cent five-year cure in the above mentioned fifteen cases of silent carcinoma which he discovered. This proves that only by early diagnosis and treatment the end results of cancer

\* From the Department of Surgery and Gynecology, John E. Cannaday, M.D. Charleston General Hospital, Charleston, West Virginia.

of the cervix can be improved and a good chance for recovery assured.

It should be kept in mind that there

Watts, suggests, therefore, that any cervical laceration with thickening and everted erosion should be regarded as "pre-



FIG. 1. Case 1. Glandular erosion of cervix, squamous cell metaplasia and small squamous cell carcinoma.

is very slow growth during the initial phase of carcinoma of the cervix. The initial phase may last for months or even several years (Nuttal, Todd, Healy, Behney).

Continuous irritation of tissue (Steiner, Smith) by chemical, bacterial and tissue extract agents, may be a predisposing factor in the development of carcinoma.

In the presence of a benign lesion, the beginning carcinoma can be easily overlooked. Most pathologists now agree that chronic inflammatory lesions, lacerations of the cervix at childbirth, and erosions are contributory factors in the development of malignancy of the cervix.

Eden Watts regards many borderline cases as suspicious but not definitely malignant. He believes that the erosion may become the seat of cancer. Beckman reports the development of a cervical carcinoma in an erosion treated by him for fifteen years.

The erosion accompanied by deep cervical laceration and thickening of the labia of the cervix is a strongly predisposing factor in the development of cancer.

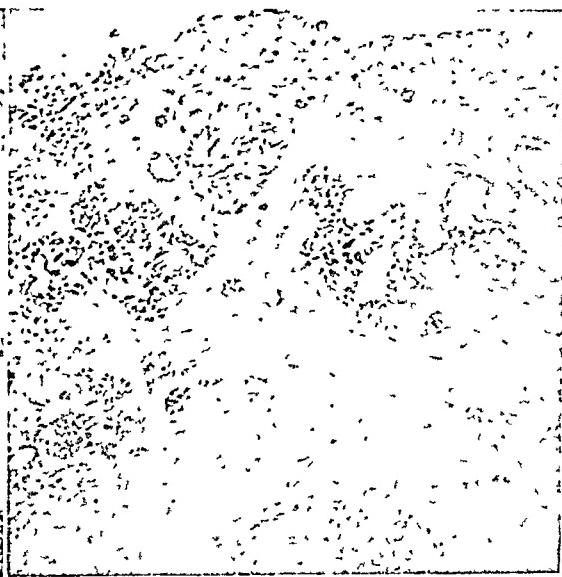


FIG. 2. Case IV. Small fragments of tissue with adenocarcinoma of the cervical canal

cancerous" and should be treated by excision.

Many pathologists resent the expression "precancerous" as they believe that a lesion is either benign or malignant, but recent experience and studies seem to indicate that there can be a transient stage between the benign and the malignant.

Goodall and Power do not believe that scars of the cervix are a contributing cause of carcinoma of the cervix but the irritation of chronic endocervicitis and ectropion may have something to do with the beginning of carcinoma of the cervix. Meyer believes that erosion of the cervix has some influence in the development of carcinoma of the cervix and states that very frequently the carcinoma arises from the margin of an old erosion.

We note a rather general belief that there is a close relation between the benign and the early malignant lesion. Nevertheless, this fact is still being overlooked, as illustrated by the following characteristic case report by Fulkerson:

"Mrs. A. was admitted to the clinic on July 21, 1922. Aged thirty-seven years. Mar-

ried 10 years. No children. Three miscarriages, last six years before. No sickness. Complaints: pain on right side and in vagina; dyspareunia

under frequent treatments over a period of twenty-two months associated with the advanced involvement found at operation, is



FIG. 3. Case II. Fairly advanced cell carcinoma located inside of the cervical canal.



FIG. 4. Case III. Squamous cell carcinoma of cervix with marked secondary infection

on and off for about two years, worse in last month. Slight discharge. Bowels regular. Uterus anteflexed, normal size. Diagnosis—cervicitis.

"The history taken and the first examination made by an experienced gynecologist and pathologist. She was treated by him and other members of his associate staff off and on for twenty-two months until May 1, 1924, when the cauterization was resorted. Considerable bleeding followed and healing did not take place. Two and a half months later the cervix was again cauterized. Improvement did not follow and the patient was referred to the hospital December 30, 1924. Examination showed erosion of the posterior cervical lip, destruction of cervical tissue up to vaginal junction, moderate erosion anteriorly and laterally about the external os with extension of carcinomatous tissue up into the cervical canal, involving by infiltration the entire cervix and with beginning parametrial involvement. Dilatation and curettage were done, followed by the insertion of 100 mg. of radium for twenty-four hours.

"The pathologic diagnosis was squamous cell carcinoma, only a small amount of normal endometrium being present.

"The complaint of pain in the vagina and increasing dyspareunia for two years, as well as the failure of the supposed cervicitis to improve

ample evidence that the disease was carcinoma from the beginning and that no change from cervicitis to malignancy occurred."

Undiscovered early malignancy of the cervix is very often mistaken for stump carcinoma. The incidence of "stump carcinoma" which, according to Ward ranges from 4.1 to 7.2 per cent, would be markedly decreased if routine biopsy preliminary to subtotal hysterectomies were done. It is not proposed to discuss in this paper the problem of total and subtotal hysterectomy, but frequently "stump carcinoma," which in many cases is nothing else but an early carcinoma of the cervix, is overlooked at the time of subtotal hysterectomy. Nuttall, Todd, Healy and Behney state that one to three years should elapse after the subtotal hysterectomy before the diagnosis of "stump carcinoma" can be made.

When performing a subtotal hysterectomy, we routinely do a radical conization of the cervix for two reasons: (1) To sterilize the cervix before doing a laparotomy, and (2) to obtain a biopsy and exclude the possibility of malignancy of the cervix.

Miller and Todd report 899 conizations done for different types of cervical disorders without any serious complication. They believe that when clearly indicated, conization is a splendid procedure.

It may seem that we have been rather radical in the use of conization but when one considers the percentage of carcinomas of the cervix, as yet relatively high, that are overlooked even by well trained gynecologists and surgeons, the procedure would seem to be justified, even in patients with less severe cervical disease in whom, according to some, simpler office methods might seem to be indicated. No seriously harmful complications ensued in any of our conization cases. Even in the superficial lesions treated by conization, the after-effects did not exceed those caused by simpler procedures.

Obtaining the right kind of specimen is a matter of importance. The pathologist can discover cancer only if the specimen he receives contains the lesion. Therefore, a poor biopsy may be worse than none. A negative biopsy report will bring a false sense of security while the carcinoma continues to grow undiscovered. Therefore, in suspicious cervices we do a radical conization with the belief that if the cervix should not be malignant, the removal of the diseased tissue may have some prophylactic value.

There are different ways of obtaining specimens for biopsy purposes: (1) excision, (2) scraping or excochleation, and (3) the use of the electrosurgical unit. We agree with Meyer, who states that the use of the electrosurgical unit for obtaining a specimen for biopsy purposes is the safest procedure as it is more apt to prevent the possibility of transplanting the carcinomatous cells into the blood stream than any other method.

Conization can be a completely bloodless procedure if the cutting and coagulation currents are well adjusted. We usually obtain a good specimen by using a rather high current so that fast cutting is achieved and only a very thin layer of the immediate

surface of the tissue specimen can be destroyed by the heat.

We classify our conizations in three categories: (1) slight, (2) moderate, and (3) radical. If the lesions are more superficial, as in an erosion or for biopsy purposes, we use slight and moderate conization. In cases of edematous, chronic, cystic cervicitis or in cases in which amputation of the cervix, Sturmdorff's operation and trachelorrhaphy have been done, we usually do a radical conization.

The conization technic, as referred to in this paper, differs somewhat from the original one described by Hines and Cherry. After thorough inspection and examination of the cervix, the type of conization to be used is decided upon. The patient is put in the lithotomy position and after the vagina and cervix are cleansed, conization is carried out with the electrosurgical unit loop, the size of the latter varying in accordance with the size of the cervix and the type of conization. The cervix is grasped with a large Allis forcep and the conization done as shown in the drawings. We do not use sutures. If bleeding occurs during the procedure, fulguration of the bleeding points is done.

We find that the most suitable time for conization is immediately after the menstrual period. Coning out the cervix just before the menstrual period or between periods may cause an increase in the menstrual flow and also bleeding from the conized area which is being macerated by the menstrual flow.

Slight and moderate conizations can be done without anesthesia and the patient allowed to go home the same day. The radical conization, however, is always done under general anesthesia, preferably sodium pentothal and oxygen. The patient is hospitalized for about three days.

Before leaving the hospital, the patient is always instructed to avoid intercourse for the next four weeks, take daily sitz baths and not to be alarmed if moderate vaginal bleeding should occur.

On the fourth or fifth day after conization, the thin necrotic layer of tissue will slough from the conized area of the cervix;

Realizing the facts described and discussed in the first part of this paper, we have come to the conclusion that early

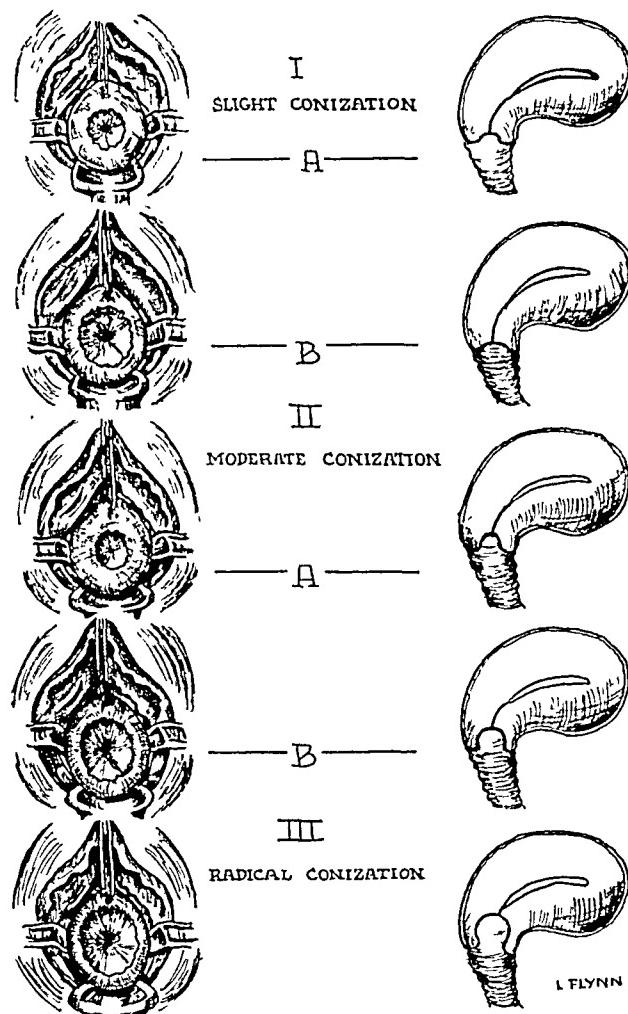


FIG. 5. Three different types of conization: slight, moderate and radical.

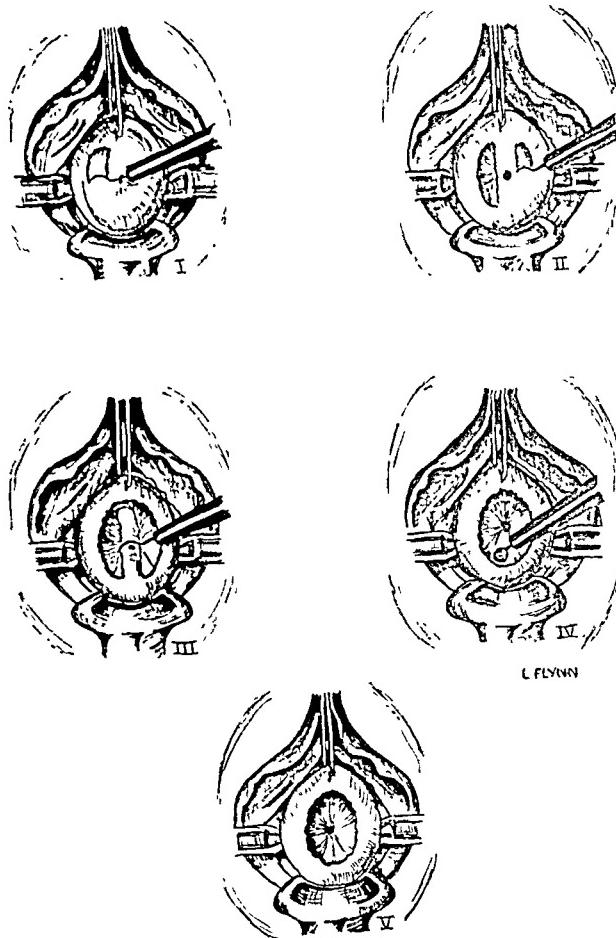
the granulation tissue underneath will have some tendency to bleed. In our series of cases, we had two patients who had to be hospitalized because of vaginal bleeding one to two weeks following conization. These patients did not follow the instructions given them when they left the hospital.

The slough has usually completely disappeared in from three to six weeks depending on the type of conization used; the cervix is smooth and has almost the appearance of a nulliparous cervix. Little if any scar tissue results from properly performed conizations.

diagnosis and early treatment of all cervical lesions are essential in the control of cancer of the cervix. There are numerous methods described for the treatment of cervical lesions. This in itself indicates that none of them is perfect. Most types of therapy used in the treatment of such lesions are based on the destruction of the diseased tissue by heat, cold, chemicals, etc. Cauterization, at present, is the most favored method of treatment in this group. The extent of the destruction of tissue by cautery is usually to a greater depth than we realize and it is difficult to predict with accuracy just how much tissue

will be affected when this method is used. Bleeding following cauterization is not rare. Extensive scar formation and stenosis

profuse vaginal discharge, also irregularity of menstrual periods. The patient had been admitted to the hospital two weeks previously



L FLYNN

FIG. 6. Conization technic (conization of the cervix).

of the cervix may occasionally result. Only moderate stricture formation could be observed in two of our patients during check-ups following radical conization. Realizing that there are not enough cervical biopsies done, we believe we have found in "conization" the most practical combination of treatment and diagnosis.

#### CASE REPORTS

**CASE I.** No. A-53349, E. W., a white female, age twenty-six years, was admitted to the Charleston General Hospital on July 26, 1943, complaining of lower abdominal pain which became more severe after menstrual periods and which was associated with fever and general malaise. There was a history of

at which time she had received conservative treatment (sulfathiazole, bed rest, etc.) for pelvic inflammatory disease.

Examination revealed marked tenderness in the left lower quadrant with a tender mass palpable in this area. On pelvic examination, both adnexal regions were very tender. A cystic mass was felt in the left fornix. The cervix was slightly eroded but mainly of normal consistency and bled only very slightly during the pelvic examination. There were no signs of induration. Temperature was 100°F., pulse 80 and respirations 20.

Laboratory examinations were essentially negative except for a leucocytosis of 19,600 leucocytes and 86 per cent neutrophils. Clinical diagnosis of chronic pelvic inflammatory disease with acute exacerbation and left tubo-ovarian abscess was made.

Operation was performed on July 31, 1943. Following a course of sulfathiazole, conization of the cervix and pelvic laparotomy were performed. Advanced chronic bilateral salpingitis with abscess formation in the left ovary was found together with hemorrhagic corpus albicans cyst on the right. The pathological report on the specimen obtained by routine conization of the cervix was glandular erosion of the cervix, squamous cell metaplasia, and small squamous cell carcinoma.

The postoperative course was complicated by a mild ileus. She was discharged August 10, 1943, markedly improved and returned on September 7, 1943, for radiation therapy of the cervix.

If cauterization instead of conization had been performed, this beginning carcinoma would have remained undiscovered and, if discovered later, would probably have been too far advanced for effective treatment.

CASE II. No. A-38345, S. W., a white female, age twenty-one, was admitted to the Charleston General Hospital on June 14, 1942, complaining of right-sided abdominal pain of four years' duration. There was a history of one living child delivered about four years ago, and an appendectomy during the time of her pregnancy. Menstrual periods were irregular, profuse and prolonged and there was a rather excessive vaginal discharge between periods. As a rule, there was considerable discomfort associated with each period.

Examination revealed a well developed and well nourished white female in no acute distress. She was apparently in a state of psychoneurotic imbalance. There was an incisional scar over the right rectus region. Some tenderness was present in the right lower quadrant. Pelvic examination revealed much scarring in the region of the left side of the cervix and adjacent vaginal wall, apparently incidental to the delivery several years previously.

Laboratory findings were essentially negative except for pus (4 plus) in a catheterized specimen of urine.

Pelvic exploration and conization of the cervix were performed on June 18. The pathological report on the conization tissue was squamous cell carcinoma of the cervical canal. Radiation therapy was instituted.

CASE III. No. A-46415; A-47265, B. S.,

a white female, age twenty-seven, was admitted to the Charleston General Hospital on April 12, 1943. There was a history of low abdominal pain and low backache with rather scanty occasional bleeding during the past two or three weeks. This patient had previously consulted her physician for similar complaints and a diagnosis of pelvic inflammatory disease had been made. A pelvic operation and cauterization of the cervix were done by this physician in September, 1942. Both tubes were found bound down with adhesions. The cornual portion of each tube was removed and the defect peritonized, the uterus suspended and routine appendectomy done.

Physical examination revealed a rather well developed individual in no acute distress with considerable tenderness through both lower quadrants. Pelvic examination revealed the cervix to be markedly eroded in an area about the size of a half dollar. This tissue was friable and bled easily on touch.

Biopsy of the cervix and conization were done on April 12, 1943. The pathological examination showed squamous cell carcinoma of the cervix with well marked secondary infection. Radiation therapy was instituted.

If conization instead of cauterization had been carried out at the time of the first operation, valuable time might have been saved and an early discovery of carcinoma might have been made.

CASE IV. No. A-46415; A-45349, M. M., a white female, aged sixty-six years, was admitted to the Charleston General Hospital January 30, 1943, with a complaint of vaginal bleeding. The patient stated that since menopause at the age of fifty-two she had not noticed any abnormality until about six months ago, when she had a considerable amount of vaginal bleeding associated with some abdominal pain, and that since that time she had had recurrent attacks of vaginal bleeding at intervals. Otherwise her general health had been good.

Examination revealed a slight tenderness in the right lower quadrant of the abdomen extending to the midline. On pelvic examination a moderate amount of blood-tinged cervical discharge was noted. The cervix was sclerotic. No pelvic masses were palpable; the uterus was not enlarged. Laboratory examination was essentially negative. X-rays of the pelvis and lumbar spine were negative.

Diagnostic dilatation and curettage and also biopsy of the cervix by radical conization were done. A frozen section revealed necrotic fibroids and chronic cervicitis. Following this subtotal hysterectomy was done.

Unfortunately in this case, the frozen section did not reveal carcinoma; however, the final pathological report on the cervical tissue revealed adenocarcinoma of the cervix. Radiation therapy was instituted six weeks later.

TABLE I

	No. of Cases
Patients treated by conization	311
Squamous cell metaplasia	11
Carcinoma of the cervix	18
Carcinoma of cervix disclosed by use of conization	4
Benign lesions of the cervix (multiple lesions occurring occasionally in one cervix) erosions, glandular cystic erosion, ectropion cervicitis (acute, chronic, cystic) endocervicitis, (acute, chronic) retention cysts, fibrosis, polyps, glandular proliferation	312

The 311 cases reported in this paper are based on conizations done at the Charleston General Hospital between July, 1942, and October, 1944.

The follow-up of our patients was rather difficult. Many of them lived a considerable distance from the hospital. Only a limited number of them could report for a personal check-up and only a little over 50 per cent of all patients who received questionnaires answered them, assisted by their local physician. Among 311 conizations, eighteen malignancies and eleven squamous cell metaplasias were found.

Some of the metaplasias were extensive and one case was highly suspicious for beginning malignancy. All patients with metaplasias were urged to return for repeated check-ups but comparatively few responded. Repeated biopsies on two patients with metaplasia who followed our advice and came in for check-ups did not reveal malignancy. The discovery of the four cervical carcinomas, 22 per cent of all the carcinomas reported in this paper, was made by conization. In none of the four reported cases did routine pelvic

examination (palpation and inspection) reveal the malignancy.

#### CONCLUSIONS

1. The difficulty in diagnosing early carcinoma of the cervix has been pointed out, and the discovery of silent carcinoma by biopsy proved.

2. The relationship of benign and malignant lesions has been stressed and also the fact that certain benign lesions may be regarded as precancerous.

3. Any cervix with signs of the pre-cancerous stage as pointed out previously, even if the lesion seems to be only superficial, should be conized. Routine radical conization should be done before subtotal hysterectomy. Radical conization, we believe, is the method of choice in all cervices with chronic cystic cervicitis and in cases in which amputation, Sturmdorff's operation and trachelorrhaphy are indicated.

4. Conization is a procedure combining treatment and diagnosis. By using high current, even very thin layers of tissue may be found as useful specimens for biopsy purposes.

5. Conization has been classified according to its use: (1) slight, (2) moderate, and (3) radical.

6. In our series of cases no more harmful after-effects have resulted from conization of the cervix, even in superficial lesions, than those following simpler office procedures.

7. After successful conization, relatively little scar tissue results and the cervix is usually restored to the appearance of a nulliparous one.

8. Early diagnosis of malignancy improves the chance of cure.

All tissue specimens were examined by Doctor Walter G. J. Putschar, Chief of the Pathological Department of the Charleston General Hospital. All microphotographs were obtained through the courtesy of Dr. H. M. Mican, Charleston, W. Va.

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# MODIFIED TREATMENT FOR FRACTURE OF THE HEAD OF THE RADIUS

CAPTAIN R. W. POSTLETHWAIT

MEDICAL CORPS, ARMY OF THE UNITED STATES

RECENTLY note has been made of the frequent unsatisfactory results obtained in the treatment of fractures of the head of the radius, and immediate active motion has been suggested as a method to procure earlier and more complete recovery. In a small series of cases at this hospital, the value of early mobilization in this type of fracture has been confirmed. The purpose of this paper is to discuss briefly the rationale for this method of treatment, and to outline modifications which have been very helpful.

Fractures of the head of the radius may be divided into three classes: (1) linear fracture without displacement, (2) comminuted fracture with slight displacement, and (3) comminuted fracture with marked displacement. In class 3, operation is usually necessary and will not be included in this discussion. With the exceptions noted below, the treatment usually recommended for classes 1 and 2 is immobilization in a plaster cast or molded splint for periods of three to six weeks. This type of treatment is usually followed by a prolonged period of physiotherapy and other measures attempting to regain the lost range of motion in the elbow joint, with variable success.

Fontaine<sup>1</sup> reported one case of comminuted fracture of the head of the radius treated by repeated periarticular novocain injection and active motion with excellent result. Ferguson<sup>2</sup> treated five fractures of the head of the radius by Fontaine's method "with excellent functional results." Stimson<sup>3</sup> suggested aspiration of the joint followed by motion within pain limits after twenty-four hours. Neuwirth<sup>4</sup> reported a small series of fractures about the elbow treated by early mobilization,

and included one case of fracture of the head of the radius. Mason and Shutkin<sup>5</sup> recorded a group of eighteen cases of fracture of the head or neck of the radius treated by immediate motion with 95 to 100 per cent recovery of function. Aspiration of the hemarthrosis and early active motion is also a procedure which has been widely used on the Fracture Service of the Presbyterian Hospital in New York.<sup>6</sup>

Mason and Shutkin<sup>5</sup> have stated the fundamental anatomic factors. The ulna and the radius articulating with the humerus form two condylar joints which do not have the same axis, nor do they move through the same arc. Perfect synchronization is necessary for full motion, and anatomic disturbance of the axis or arc of either joint will produce some degree of mechanical block. An anatomic reduction is essentially impossible, immobilization until bony union occurs will result in loss of synchronization and bony blocking, as evidenced by decrease in range of motion. By immediate active motion, however, the fractured head of the radius moves across the uninjured, fixed surface of the humerus, and the fragments thus attain the best functional position in relation to the various joint surfaces. It may be added that the orbicular ligament will prevent further displacement in this type of fracture.

The diagnosis of these fractures usually presents no difficulty, although occasionally special oblique roentgenograms are necessary to visualize the fracture line. The patient complains of increasing pain and decreasing motion, most often beginning one to three hours after injury. Examination showed marked limitation

of motion, particularly pronation and supination, bulging of the joint capsule, and tenderness over the head of the radius.

formed by the head of the radius, the lateral epicondyle and the tip of the olecranon there will be found a fluctuant

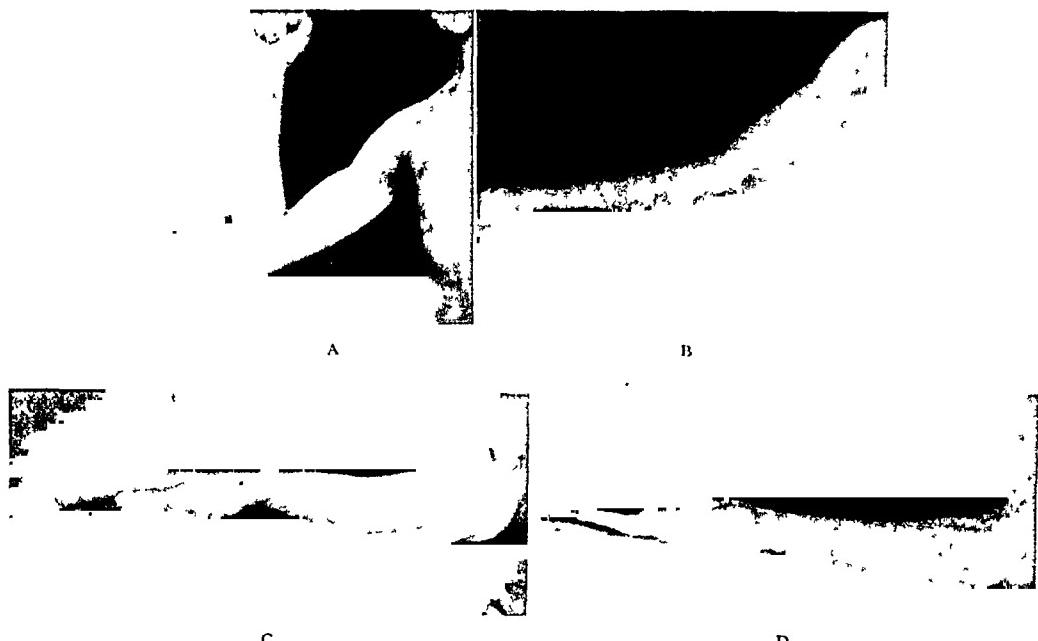


FIG. 1. Showing degree of flexion, extension, pronation and supination twenty-four hours after joint aspiration and procaine injection. Motion was painless and not forced. On admission, twenty-eight hours after fracture, flexion was to 100 degrees, extension 120 degrees, and pronation and supination 40 per cent of normal.

Even at rest the pain due to the hemarthrosis is marked.

After the diagnosis has been established

swelling representing the distended joint capsule. A small wheal is raised in the center of this triangle, using 1 per cent procaine, and an 18 or 19 gauge needle introduced into the joint. From 15 to 30 cc. of blood may be obtained, with pressure being made on the anterior and posterior pouches of the joint. From 5 to 8 cc. of 1 per cent procaine is then injected into the joint. If the aspiration is performed soon after injury and before the bleeding has stopped, reaccumulation of blood may necessitate a second aspiration and injection.

There will follow marked relief of the pain and an increase in the amount of motion without pain. The arm is placed in a sling. For the first seven days after injury, the patient is instructed to remove the arm from the sling four times daily, exercising the elbow within pain limits for about twenty minutes each time. The sling is removed after a week, and the patient allowed to begin simple tasks using the



FIG. 2. Roentgenogram of patient in Figure 1; linear fracture with slight separation; class A.

the elbow is shaved and the skin prepared with ether, iodine and alcohol. In a triangle

arm, but always taking care to remain within pain limits.

No hot packs, diathermy, massage, or

of the radius with little or no displacement, and have been placed in class 1. Two had moderate displacement of the frag-



FIG. 3. Roentgenogram of class B fracture, with displacement of the fragment.

other physiotherapy is given for the following reasons: The early pain is eliminated largely by joint aspiration and procaine injection. Circulation about the elbow joint is adequate, and no stimulation for improved blood flow is necessary. More important, by placing the responsibility of increasing the motion directly upon the patient, no dependence upon the physiotherapist is developed by the patient and greater effort to regain the motion will be made by him. The patient is instructed and encouraged each morning at rounds, and thus far the response has been excellent.

The time of discharge from the hospital varies with the particular job to which the soldier is assigned, those performing light office work being released earlier than those doing full field duty. No heavy work is allowed until it is thought that firm union has occurred. Frequently, a short convalescent furlough is given.

Earlier, six patients were treated in a manner similar to that suggested by Mason and Shutkin, with excellent functional results in much shorter time than those treated by the conventional method. More recently, eight patients have been treated by the method outlined above. Six of the latter group had a fracture of the head

ment, and have been placed in class 2. To determine the length of hospitalization would be of no value in this series. The assignment of two of the soldiers was such that they were allowed to return to duty immediately after treatment, reporting to the clinic frequently for observation. Others were given convalescent furloughs, thus permitting discharge earlier than would have been possible otherwise. A few patients remained in the hospital until it was believed that they could perform reasonably heavy work. In the average case about fourteen days' hospitalization is required, with return to light duty in four weeks and full duty in six weeks. The recovery of function has been complete in all cases except one patient (class 2) who lacks full extension by less than 5 degrees.

An accurate determination of the time required for complete recovery is very difficult in these cases, in both military and civilian patients. Nevertheless, with joint aspiration, procaine injection and immediate active motion, the patient is rarely absent from duty more than three to five weeks and may not lose even one full day. This is in marked contrast to those treated by immobilization, when the soldier

may need seven to ten weeks' treatment before returning to duty.

#### SUMMARY

Fractures of the head of the radius which do not show marked displacement will recover more promptly and completely if treated by joint aspiration, procaine injection into the joint and immediate active motion. The aspiration of the hemarthrosis and the injection of procaine will produce relief of the severe pain which occurs soon after injury, and will permit earlier increase in the range of motion.

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THE commonest cause of delayed union in closed fractures is inadequate splinting. Fractures in certain locations as the neck of the femur and the wrist joint unite more slowly than the average. Most cases respond to further immobilization and frequent applications of heat.

From "Fractures and Dislocations for Practitioners" by Edwin O. Geckeler (The Williams & Wilkins Company).

# THE RÔLE OF LYMPHOID HYPERPLASIA IN ACUTE APPENDICITIS\*

H. REMBERT MALLOY, M.D.,  
Resident in Surgery, Freedman's Hospital

ROBERT S. JASON, M.D.  
Professor of Pathology, Howard University  
School of Medicine

AND

CHARLES R. DREW, M.D.  
Professor of Surgery, Howard University, School of Medicine  
WASHINGTON, D. C.

THE frequency with which abdominal pain has been noted in the course of infections of the upper respiratory tract, has led to many investigations in an effort to determine what relationship, if any, may obtain between the two.<sup>5,6,17,23</sup> The earlier studies of this association brought out the fact that many of these cases have an associated mesenteric lymphadenitis or hyperplasia of the lymphoid tissue of the intestines.<sup>1,9,14</sup> Other investigators have reported lymphoid hyperplasia and mesenteric lymphadenitis in the course of infections of the gastrointestinal tract, e.g., acute gastro-enteritis, typhoid fever, and tuberculous enteritis.<sup>7,13,14,18,19,20</sup>

It is accepted that lymphoid hyperplasia takes place in many subjects as a part of a generalized response of lymphoid tissue to the presence of infection; and that the lymphoid tissue of the appendix may share in this response is supported by the observations of Bowers,<sup>4</sup> Gray and Heifetz<sup>10</sup> and Held and Goldbloom.<sup>11</sup> Schroeder<sup>22</sup> and Sauer and Bailey,<sup>21</sup> reported the occurrence of appendicitis with tonsillitis, and Behrend<sup>2</sup> believes that "throat infections" are a contributing factor in the etiology of many cases of appendicitis. Bothe and Pote<sup>3</sup> reported the finding of an acutely inflamed appendix in an individual with an acute gastro-enteritis.

In support of the Aschoff theory of the origin of appendicitis Gray and Heifetz<sup>10</sup>

expressed the belief that lymphoid hyperplasia in the appendix may cause stasis in the mucosal crypts due either to occlusion of the appendiceal lumen or of the crypts themselves. With stasis in the crypts, inflammation within them may soon follow, spreading in the form of acute suppurative or gangrenous appendicitis.

TABLE I  
APPENDICITIS  
Pathological Diagnosis and Mortality

Diagnosis	No.	Deaths	Mortality, Per Cent
Gangrene without perforation	16	0	0
Gangrene with perforation	17	3	17.5
Suppurative without perforation	75	1	1.3
Suppurative with perforation	17	0	0
Acute non-suppurative	129	0	0
Raised intraluminal pressure alone	41	0	0
Peri-appendicitis	7	0	0
Chronic fibrosis with obliteration of lumen	10	0	0
Enterobius infestation	2	0	0
Tuberculous	2	0	0
No pathological diagnosis	40	0	0
Totals	356	4	1.12

Wangensteen and Dennis<sup>24</sup> are of the opinion that appendicitis begins as a closed loop obstruction and list lymphoid hyperplasia as one of the factors which may be responsible for the obstruction.

\* From the Departments of Surgery and Pathology, Howard University, School of Medicine and the Division of General Surgery, Freedmen's Hospital, Washington, D. C.

These views are also shared by McCallig.<sup>16</sup> Here the obstruction is intraluminal; however, Urech<sup>23</sup> has observed cases in which obstruction in the appendix was caused by compression from without by enlarged lymph nodes at the base of the appendix.

These recorded observations and impressions pointing to a close correlation between the occurrence of acute inflammation of the appendix and the presence of acute infectious processes elsewhere, prompted a critical evaluation of the records of all the patients operated upon over a three-year period in this clinic with a clinical diagnosis of acute appendicitis. This review revealed 356 patients operated upon from July 1, 1940, to June 30, 1943, with a total mortality rate of 1.12 per cent. The pathologic diagnosis and mortality rates are listed in Table I.

There were fifty-seven cases (16.01 per cent) found in which lymphoid hyperplasia was listed prominently among the pathological findings. The clinical and pathological findings in these cases are listed in Table II. That infection is a prominent factor in these cases is shown by the incidence of forty-eight cases (84.2 per cent) or 13.3 per cent of the total series. The distribution of the infections is noted in Table III.

It is significant to note that forty-four cases (78.5 per cent) of the fifty-seven had an associated finding of raised intraluminal pressure. In the total series there were observed one hundred cases (27.7 per cent) in which raised intraluminal pressure was noted on pathological examination. They were distributed as noted in Table IV.

In many of those cases in which suppuration or gangrene had caused destruction of the walls no definite diagnosis of lymphoid hyperplasia or increased intraluminal pressure could be made.

In this series the cases in which lymphoid hyperplasia was so prominently a feature were characterized by a history of an upper respiratory infection or gastrointestinal upset for a few days to a week or ten days and gradually or suddenly de-

TABLE II  
CLINICAL FINDINGS IN THE CASES OF APPENDICITIS  
SHOWING LYMPHOID HYPERPLASIA

Findings	No.	Per-cent-age	Per-cent-age in Total Series
Associated or concomitant infection.....	48	84.2	13.3
Average days of incubation.....	4		
Average age.....	18.5		
Generalized pain initially.....	25	43.8	6.83
Right lower quadrant pains initially.....	32	55.2	8.98
History of recurrent attacks.....	31	54.4	8.7
Incidence of colicky pains.....	32	55.2	8.98
Nausea.....	47	82.5	13.2
Vomiting.....	40	70.2	10.94
Soft abdomen.....	45	78.9	12.65
Flat abdomen.....	47	82.5	13.2
Splinting (involuntary).....	12	21.05	3.37
Average temperature.....	99 <sup>1</sup>		
White blood count without complications.....	9,500		
White blood count with complications.....	12,175		
Gangrene.....	2	3.5	.56
Gangrene with perforation.....	2	3.5	.56
Suppurative.....	9	15.8	2.46
Suppurative with perforation.....	1	1.75	.28
Acute non-suppurative.....	23	4.03	6.46
Raised intraluminal pressure.....	15	26.3	4.21
Lymphoid hyperplasia alone.....	4	7.03	1.12

TABLE III  
TYPE OF ASSOCIATED INFECTIONS IN CASES OF APPENDICITIS WITH LYMPHOID HYPERPLASIA

Type of infection	No.	Per-cent-age	Per-cent-age in Total Series
Upper respiratory.....	37	64.9	10.3
Gastro-enteritis.....	6	10.5	1.69
Other general infections.....	5	8.7	1.4
Total.....	48	84.2	13.3

velops colicky abdominal pains. In many cases the preceding infection may have only a brief interval between its onset and the onset of abdominal symptoms. The abdominal pains may begin and end in the right lower quadrant or they may be generalized at first and later become

localized in the right lower quadrant, findings which are common in appendicitis in general. The attacks are usually recurrent and the increased frequency or increased severity of the abdominal symptoms forces the patient to seek relief. Nausea and vomiting are usually present and the occurrence of anorexia is found in every case in which the inflammatory process in the appendix is severe.

TABLE IV  
CAUSES OF RAISED INTRALUMINAL PRESSURE

Group	No.	Percentage in Total Series
Lymphoid hyperplasia	44	12.38
Adhesions	23	6.45
Fecaliths	11	3.08
No discoverable cause	22	6.18
Total	100	27.1

The abdominal findings enhance the approach toward a correct diagnosis. In early cases in which the main pathologic process is lymphoid tissue reaction with or without closed loop obstruction but without inflammation, the abdomen is usually flat and soft. However, in the apprehensive or anxious patient voluntary splinting may be noted. Only in the advanced case do you find involuntary splinting. There is tenderness over the base of the appendix; rebound tenderness and Rovsing's sign may be present. If suppuration, gangrene or perforation have occurred the other well known signs of peritonitis will be present. The rectal examination may reveal definite information, depending upon the stage of the process. If suppuration is not present, there may be no rectal tenderness and if there is tenderness it is usually slight. However, if suppuration is present, definite tenderness is noted upon tugging on the peritoneum, or and if perforation has occurred a mass may be noted.

The temperature is usually normal or slightly elevated, except in those cases in which the primary infection accompanies

the abdominal symptoms. In these the temperature depends in all probability upon the extent of the primary infection. This fact may lead to confusion unless the entire clinical picture is appraised.

The white blood count is usually below 10,000, but again when the primary infection is present and inflammation has been added to the appendix, the white blood count is influenced by this and is above 10,000 in the majority of cases.

In this series, many of these patients when first seen were considered as cases of acute mesenteric lymphadenitis or subsiding appendicitis, yet they were operated upon in order not to incur the risk of overlooking an irreversibly inflamed appendix.<sup>3,15,23</sup> It is the conviction in this clinic that it is to invite disaster to discharge a patient with a diagnosis of acute mesenteric lymphadenitis without a period of observation. We agree that it is better to remove, through a McBurney's incision, a normal appendix<sup>20,22</sup> or one just showing increased intraluminal pressure with lymphoid hyperplasia than to send the patient home to develop a closed loop, suppuration, gangrene and perforation. These opinions stem in part from personal observations, for some of our cases, believed to have had merely mesenteric lymphadenitis, were observed and they developed under observation a typical picture of acute appendicitis, about which there was no doubt; and at operation an acutely inflamed appendix with increased intraluminal pressure and lymphoid hyperplasia were found.

#### CASE REPORTS

CASE 1. P. C., aged eleven years, female, was admitted complaining for three days of generalized colicky abdominal pains which later localized in the right lower quadrant. The attack was accompanied by a sore throat and was associated with nausea, vomiting and anorexia. Previous attacks were admitted, each preceded or accompanied by sore throats.

Physical examination revealed the following significant findings: a temperature of 100°F.; enlarged and injected tonsils; a hyperemic pharynx; enlarged cervical lymph nodes; a flat and soft abdomen with tenderness of deep

palpation over McBurney's point; rebound tenderness referred to the right lower quadrant and a positive Rovsing's sign was present; and mild rectal tenderness was present on the right.

The accessory clinical findings revealed the urine to be entirely normal. The white blood count was 10,150, with 78 per cent neutrophils and 22 per cent lymphocytes. The other laboratory data had no bearing on the complaint.

The patient was observed for twenty-four hours. During this time the tenderness persisted, and an appendectomy was advised. The pathologist (R. S. J.) reported a subsiding diffuse suppurative and ulcerative appendicitis with lymphoid hyperplasia and increased intraluminal pressure.

**CASE II.** C. E., aged twelve years, male, was admitted complaining of right lower quadrant abdominal pains of one week's duration. The pains were colicky in character at the beginning, but later became dull. Nausea, vomiting and anorexia were present during the last three days of his illness, and he admitted having a "cold" for two weeks.

Physical examination revealed a dehydrated, well nourished individual with a temperature of 101°F., a pulse of 130, and a respiratory rate of 26. There was a foul odor to the breath. The left tonsil was hyperemic and the right tonsil was hypertrophied. There was a purulent exudate present in the pharynx. The abdomen was soft and flat with tenderness about 2.5 cm. medial to and below McBurney's point. Rovsing's sign was positive and rebound tenderness was generalized, but more marked in the right lower quadrant. There was moderate rectal tenderness on the right and slight tenderness on the left. The inguinal and cervical nodes were enlarged but not tender.

The white blood count on admission was 13,450 with 81 per cent neutrophils. Twenty-four hours later the white blood count was 26,000 with 93 per cent neutrophils. The urine was negative.

The patient was observed for twenty-four hours. During this time an attempt was made to restore his fluid balance by oral and parenteral routes. The symptoms progressed suggesting that the patient had developed an acute appendicitis. A gangrenous appendix with lymphoid hyperplasia was removed.

**CASE III.** E. H., aged ten years, male, was admitted complaining of dull para-umbilical pains of twenty-four hours' duration associated

with nausea, vomiting and anorexia. There was no disturbance in bowel habits. The onset of abdominal pains was preceded for about a week by a severe "cold" and sorethroat.

Physical examination revealed a well developed male child in no apparent distress. His tonsils were enlarged and hyperemic. The cervical and axillary lymph nodes were enlarged, freely movable, and non-tender. There were scattered râles over the bases of the lungs, but no evidence of consolidation was present. The abdomen was flat and soft with generalized mild tenderness, and exquisite tenderness in the region of McBurney's point. Rebound tenderness was generalized and Rovsing's sign was positive. There was a positive psoas test on the right and a suggestive one on the left. No masses were palpated. There was no rectal tenderness or mass.

The temperature on admission was 100°F., and the white blood count was 14,300. Two days later the white blood count was 13,950 with a slight increase in neutrophils. The other laboratory findings bore no relation to the complaint.

During the first twenty-four hours after admission the patient was given sulfathiazole and oral and parenteral fluids. He was examined at frequent intervals. On the morning of the second day after admission the pains became colicky in character and involuntary splinting of the right side of the abdomen was noted. It was believed that the patient had developed an acute appendicitis. Through a McBurney's incision the appendix was removed. It was reported by the pathologist (R. S. J.) as an acute suppurative appendicitis with lymphoid hyperplasia and evidence of markedly increased intraluminal pressure.

**CASE IV.** E. B., aged forty-nine years, female, was admitted to the medical service complaining of generalized, crampy, abdominal pains and diarrhea for six days. The gastrointestinal upset followed a meal of fresh cold pork. Nausea was severe, but there was no vomiting. Anorexia was present. Three days prior to admission the stools became black in color. Previous gastrointestinal upsets were denied.

Physical examination revealed an acutely ill patient with a temperature of 103°F., with rapid respirations and a tendency toward restriction of motion in the lower chest. The lung fields were clear. The abdomen was

markedly distended and very tense with a suggestion of involuntary splinting. Tenderness was generalized, but more marked in the left upper quadrant. No masses were palpated. The abdomen was tympanitic throughout and there was striking silence on auscultation. The rectal examination showed exquisite tenderness high in the abdomen and on manipulation of the uterus. Vaginal examination revealed no additional information.

The white blood count was 14,750 with 88 per cent neutrophils. Twelve hours later the white blood count was 20,125 with 93 per cent neutrophils, and the hematocrit was 38 per cent. The urine showed a specific gravity of 1026, plus 2 albumen, and a plus 3 Benzidene test. A scout film of the abdomen failed to reveal any evidence of a ruptured viscus.

A surgical consultation twenty-six hours after admission revealed findings suggesting an acute condition of the abdomen with the patient in impending shock. The differential diagnosis included: (1) ruptured peptic ulcer because of the site of onset, gradual shifting of pain down right gutter and reported blood in the stool; (2) possibility of a severe gastroenteritis with secondary involvement of the appendix and generalized peritonitis with a paralytic ileus. When conservative measures had failed to relieve the distention, shock and respiratory embarrassment, an exploratory laparotomy was done with the hope of bringing about some decompression and controlling the source of contamination. A gangrenous ruptured appendix and generalized peritonitis was found. The patient expired forty-five minutes after anesthesia was begun, exactly thirty-one hours after admission.

The postmortem examination revealed a generalized fibrinopurulent peritonitis; marked generalized mesenteric lymphadenitis; submucosal petechial hemorrhages in the stomach and small intestines; cloudy swelling in the liver, and bronchopneumonia.

#### COMMENTS

Cases I, II, and III were admitted with a diagnosis of acute mesenteric lymphadenitis associated with an upper respiratory infection and were observed for twenty-four hours or longer. In Case I, appendicitis was probably present before the patient was admitted to the hospital

and was subsiding when she was first seen. However, because of the persistent tenderness an appendectomy was performed. This patient presented a history of previous attacks of abdominal pains associated with sore throats, findings which are not unusual in cases of mesenteric lymphadenitis.<sup>1</sup> The presence of colicky pains suggested an obstruction. In addition to the factors which are known to play a part in predisposing to serious infection of the appendix, once the organ has been obstructed it is quite possible that another mechanism plays a part in a case such as the one under consideration. It is quite likely that in such a case the respiratory infection is mild in character and subsides early, allowing the process in the appendix to subside before complications set in.

Cases II and III progressed while under observation. There was an increased neutrophilia, the symptoms and findings changed from mild to severe, and the appendix in both cases showed an advanced pathological state. In Case II the abdominal pains were colicky in character at the onset suggesting appendiceal obstruction from the onset.

In Case III the initial abdominal pains, although confined to the right lower quadrant, were dull in character and later became colicky. Shortly after the appearance of the colicky pains, involuntary abdominal splinting was noted, suggesting involvement of the peritoneum. It was believed that an acute suppurative appendicitis was the most likely cause. This was confirmed by surgery. Here it is believed that the initial abdominal symptoms and findings were due to an acute mesenteric lymphadenitis. The dull pains were due to edema of the nodes, and the localization of the pain in the right lower quadrant was due to the fact that the mesenteric nodes are more abundant in the ileocecal region.<sup>12</sup> As the primary infection progressed an increased lymphoid response occurred with an ultimate involvement of the lymphoid tissue of the appendix, resulting in an obstruction which progressed to suppuration before the ap-

pendix was removed. The occurrence of the colicky pains probably coincided with the involvement of the lymphoid tissue in the appendix.

Case IV in the early stages probably represented a simple uncomplicated acute gastro-enteritis, but as the infection continued the regional lymph nodes became involved with subsequent involvement of the lymphoid tissues throughout the abdomen including the appendix. The exact time of the appendiceal involvement could not be determined because the patient was too toxic to give a clear and detailed history. As the primary infection continued, the obstruction in the appendix progressed with gangrene and perforation being added. Probably if the picture had not been complicated by an acute gastro-enteritis, the time the appendiceal symptoms developed might have been noted and a correct diagnosis could have been made, resulting in a more favorable outcome.

#### SUMMARY

1. In a series of 356 patients operated upon with a clinical diagnosis of acute appendicitis fifty-seven or 16.1 per cent showed on microscopic examination lymphoid hyperplasia as a prominent pathological finding.

2. In forty-eight or 84.2 per cent of these fifty-seven cases showing lymphoid hyperplasia there was a history of concomitant or preceding infectious process.

3. In one hundred cases which showed evidence of raised intraluminal pressure, lymphoid hyperplasia in the appendix appeared to be an etiological factor in forty-four cases.

4. The clinical picture in cases of appendicitis caused by lymphoid hyperplasia is discussed.

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# MUSCLE HERNIAS OF THE LEG\*

## REVIEW OF LITERATURE AND REPORT OF TWELVE CASES

MAJOR HAROLD E. SIMON AND FIRST LIEUT. HUGO A. SACCHET  
MEDICAL CORPS, ARMY OF THE UNITED STATES

MUSCLE hernia, or protrusion of muscle tissue through a defect in the fascia which confines it, has received relatively scant consideration in the literature. The condition, however, is not rare, and a more careful consideration of the subject is warranted, particularly in view of its frequent recognition in military personnel.

### LITERATURE

Ihde,<sup>1</sup> in 1929, reported twelve cases of muscle hernia of the leg and one of the thigh, all in military personnel. He reviewed the literature carefully and stated that the earliest description was by Richet<sup>2</sup> in 1855, and that by 1881 thirty-five cases of all types of muscle hernia were reported, five of them in the leg. From then to 1901 nine additional cases were reported, making a total of fourteen cases of muscle hernias of the leg.

Ihde quoted the investigations of Fére<sup>3</sup> in 1900, who found thirty-one cases of hernia of the leg in 204 institutional epileptic patients, and of Pichon<sup>4</sup> who in 1906 reported thirty-nine muscle hernias and aponeurotic ruptures in 217 Alpine soldiers. Ihde, however, questioned the diagnosis in some of the latter series because only two of them were of a permanent nature. He states that Hesse<sup>5</sup> in 1921 first repaired these hernias with fascia transplants.

Ihde divided the muscle hernias into traumatic and constitutional or distention hernias, the former arising as a result of direct or indirect violence and the latter arising slowly, with very little discomfort, and which he held to be a part of the phenomena somatically characteristic of a

general mesodermal insufficiency; but specific evidence of such insufficiency to support this theory was not found in his case reports.

Following this report, little was written about the subject for a number of years. Among others, Haldeman and Soto-Hall,<sup>6</sup> in 1935, and Hartzell,<sup>7</sup> in 1936, each reported a hernia of the tibialis anticus muscle from direct injury successfully repaired by sutures from the fascia lata. Conwell and Alldredge<sup>8</sup> reported two cases, one a hernia through the fascia lata which they believed to be strangulated but not proven surgically, and one a hernia of the gastrocnemius muscle from a gunshot wound of the leg which was also not treated surgically because of absence of symptoms.

Since the present mobilization of the army, Schaefer<sup>9</sup> reported thirteen cases, Kitchin and Richmond<sup>10</sup> three cases, and McMaster<sup>11</sup> thirty-eight hernias in twenty-one patients, all in 1943, and the present report deals with twelve additional patients with twenty-four hernias. All of these reports have been limited to military personnel.

In all, Ihde mentioned ninety-three cases of muscle hernias of the leg reported in the literature and added thirteen of his own. We have been able to find reports of forty-five additional patients which, with ours, makes a total of 163 cases of muscle hernias of the leg. This does not represent a complete review of the literature, however.

### CASE REPORTS

The observations in twelve cases of muscle hernias of the leg form the basis of this discussion; three were due to direct

\* The drawings were made by Pfc. Kermit R. Finley.

injury and nine were of the idiopathic or indirect type.

CASE I. A nineteen year old soldier cut the lateral aspect of the middle third of the right leg with an axe in 1940. The wound was closed with four sutures. One week after removal of the sutures, separation of the wound occurred with purulent discharge; healing resulted two weeks later. He was symptom free until his basic training in the army in February, 1943, when a small swelling appeared at the site of the old injury. The swelling progressively enlarged for two to three weeks and then remained stationary. It increased in size when standing on the toes and became smaller when the leg was elevated. A dull pain was experienced in this region after calisthenics, walking or driving a car.

Examination revealed a wide, slightly depressed, adherent scar just below the midportion of the anterolateral aspect of the right leg. On dorsiflexion of the foot, and on standing, a mass about 2 or 3 cm. in diameter appeared at this site. It was uniformly soft, semi-fluctuant and partly reduceable on pressure and on plantar flexion of the foot, revealing a sharp-edged, oval defect in the anterior tibial fascia. Neither thrill nor bruit were present.

At operation under local anesthesia, the scar was excised and dissected free from the underlying tibialis anticus muscle which protruded through an oval defect in its fascia, approximately 3.5 by 5 cm. (Fig. 1.) The muscle tissue appeared normal, but was intimately attached to the overlying scar tissue. The edges of the fascial defect were smooth, firm and tense and the fascia was loosely adherent to the underlying muscle. The muscle was separated from the fascia and reduced. An attempt was made to approximate the edges of the defect but even when its attachments to the tibial periostium were cut, the fascia constituting the inner border could not be mobilized outward due to its rigidity and tenseness.

A patch of fascia lata a little larger than the defect was removed, stripped clean and sutured snugly over the defect with multiple interrupted sutures of No. 70 white cotton thread. (Fig. 2.) The skin and subcutaneous tissues were closed with similar sutures and a dressing and elastic bandage applied snugly from the toes to the knee.

The foot was flexed and extended passively once daily to prevent adhesions but motion was otherwise prohibited. The wound healed primarily, the patient was permitted up on crutches on the fourteenth day, and allowed to walk after three weeks. There was free motion of the foot and ankle and absence of all deformity and discomfort.

CASE II. A twenty-seven year old soldier fractured the middle third of the left tibia in April, 1936. Two months later, because of non-union, an open reduction was performed. After a prolonged convalescence of eighteen months, recovery was complete except for a small elevation lateral to the site of fracture on the side opposite the surgical repair. The mass was tender and pain radiated into the ankle. The resultant disability led him to seek a sedentary type of employment. During his basic training in 1942, the mass enlarged and pain and tenderness became severe enough to interfere seriously with drill and marching.

Examination revealed a vertical scar on the anteromesial aspect of the middle third of the left leg. On the anterolateral surface over the belly of the tibialis anticus muscle, there was a soft, tender, semi-fluctuant mass measuring 8 by 5 cm. Tenderness was present over the mass and along the medial aspect of the tibia.

The mass increased markedly in size with plantar flexion and when the patient stood on his toes. It decreased markedly in size with dorsiflexion of the foot or when the leg was elevated. It could be partly reduced on pressure and the edges of a fascial defect could be indistinctly outlined. No thrill or bruit were elicited. The overlying skin and the vessels of the leg appeared normal. Muscle hernia was considered in the diagnosis, as well as lipoma and angioma, and surgery advised.

At operation, under local anesthesia, a curved incision was made along the outer border of the mass and the overlying skin dissected free, revealing a mass of muscle tissue protruding through an irregular defect in the tibialis anticus fascia. (Fig. 3.) The defect measured 8 cm. in its vertical and 5 cm. in its horizontal dimension. The edges were adherent to the underlying as well as to the protruding portion of the muscle, preventing its complete reduction.

The edges of the fascia were dissected free and the adhesions separated from the under-

lying muscle for a distance of 5 or 6 cm. Closure of the defect with a single fascia lata transplant was not feasible because of its size.

Tissues were closed throughout with interrupted sutures of No. 70 white cotton thread. A large, soft gauze pad, a pressure bandage and a thin

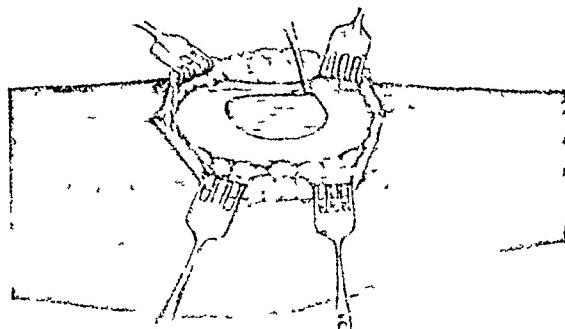


FIG. 1. Case 1. Muscle hernia through defect in tibialis anterior fascia.

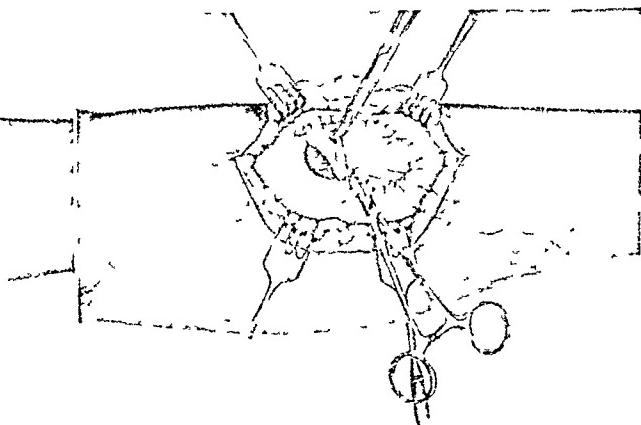


FIG. 2. Case 1. Repair of defect of tibialis anticus fascia with fascia lata transplant.

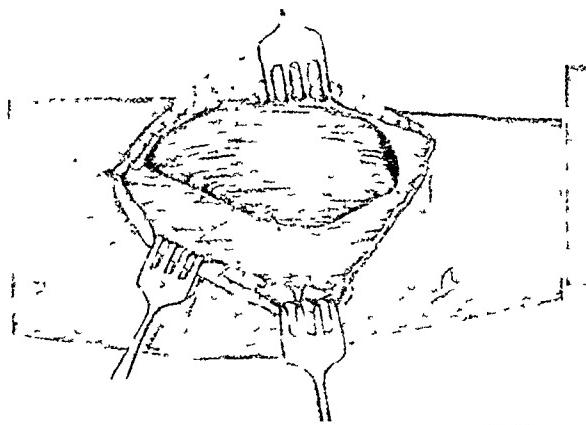


FIG. 3. Case 11. Muscle hernia through tibialis anticus fascia.

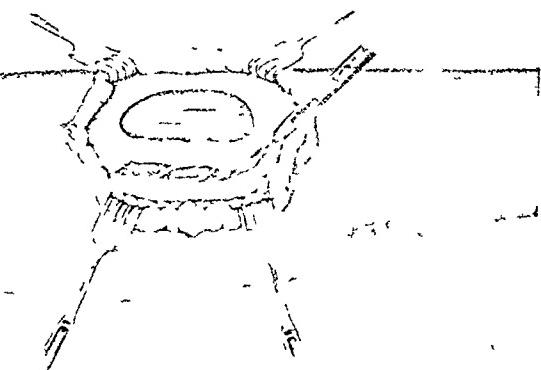


FIG. 4. Case 11. Narrowing of defect by parallel lateral incision and sliding strip of fascia medially.

An attempt was made to narrow it by separating the fascia medially from its attachment to the tibia, but mobilization on this side was impossible due to its rigidity. Laterally, a strip of fascia was shifted inward for a distance of about 1.5 cm. when a lateral parallel incision was made, thus narrowing the defect correspondingly. (Fig. 4.) The two resultant defects were repaired by means of narrow strips of fascia lata woven back and forth between the two borders of each defect. The fascial strips were anchored to each other and at the points of their passage through the borders of the defect with interrupted sutures of No. 70 white cotton thread. (Fig. 5.) Throughout the operation, the fascia and all exposed surfaces were kept covered with warm saline packs. The skin and subcutaneous tis-

plaster of paris cast were applied. Because of prolonged wound exposure necessitated by the operation, a heat cradle was placed over the leg and sulfathiazole was given orally for the first three days.

Postoperatively, there was no discomfort in the wound but there was moderate swelling of the foot and ankle which subsided when the cast was bivalved. There was temperature elevation within twelve hours to 101°F., associated with headache, generalized aching, malaise and nausea. These symptoms promptly subsided on withdrawal of the sulfathiazole and convalescence thereafter was uneventful. The sutures were removed on the tenth day; the cast was removed at the end of two weeks. At the end of the third week, walking was

permitted. There was no evidence of recurrent swelling or symptoms.

**CASE III.** A twenty-three year old soldier

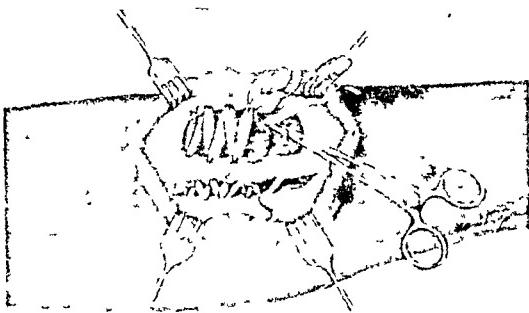


FIG. 5. Case II. Repair of defect by strips of fascia lata.

gave a history of a fracture of the right leg in 1937. Soon afterward a swelling appeared at the site of the fracture. There was moderate aching after excessive walking.

On examination, there was a semi-fluctuant round mass on the anterolateral aspect of the mid-portion of the right leg, at the site of the old fracture. The mass disappeared with the foot in dorsiflexion and enlarged with plantar flexion. It disappeared when the leg was elevated and was reducible on pressure, leaving a definitely outlined, palpable defect in the anterior tibial fascia about 1.5 cm. in diameter. At aspiration, nothing was recovered.

A diagnosis was made of herniation of the tibialis anticus muscle through a defect in its fascia. Because of the mildness of the symptoms, surgery was not advised.

**CASE IV.** A soldier, aged twenty-nine years, presented himself at a routine physical examination without complaints. Three circumscribed swellings were present on the right leg: one had appeared eight years previously while engaging in football and track, two had been present for three years. The onset had been gradual and without apparent cause, the appearance of one had been immediately preceded by a spontaneous subcutaneous hemorrhage. He had received no direct injuries to the legs. There was no tenderness, pain or other associated symptom.

On examination, an oval elevation was present about 3 cm. lateral to the mid-portion of the right tibia; it became prominent with standing on the toes and plantar flexion of the

foot; it disappeared on dorsiflexion and on elevation of the leg, and was reducible by pressure revealing an oval defect in the fascia. Two circumscribed elevations were present on the lateral aspect of the right ankle, one above the other, about 4 cm. above the shoe tops. They enlarged on standing on the heel, and became smaller when standing on the toes and were little effected by flexion and extension of the foot. Reduction was accomplished without tenderness by pressure, revealing oval defects in the fascia. Treatment was not advised because of absence of symptoms.

**CASE V.** A thirty-six year old soldier complained during a routine physical examination of aching in the right leg, on the outer aspect and into the arch of the foot, aggravated after walking. Eight or ten years previously he had been quite active playing often eight sets of tennis daily. Five and three years previously he had been in automobile accidents but had suffered no direct injury to the legs in either accident. For about two years, three swellings had been present on the right leg; they had enlarged gradually and were not tender. In civilian life he had been a truck driver; during thirteen months' service in the army, he had not undergone any strenuous exercise.

On examination, two symmetrically placed oval swellings were present on the lateral aspect of each leg, about 4 centimeters above the malleoli, one above the other. A fifth was situated on the anterolateral aspect of the mid-portion of the right leg and a sixth on the medial aspect of the middle of the left leg. (Fig. 6.) They measured .8 to 1 cm. in diameter and were oval to round in shape. On plantar flexion and when standing on the toes the swellings became more prominent; on dorsiflexion and when the legs were elevated, they disappeared. Reduction was accomplished in each instance by pressure revealing sharp-edged round or oval fascial defects. Multiple, spontaneous muscle hernias were diagnosed but because of the mildness of symptoms, surgery was not advised.

**CASE VI.** A medical officer, aged twenty-nine years, demonstrated a soft, semi-fluctuant tumor about 1 cm. in diameter situated about 2 cm. lateral to the mid-portion of the right tibia, present for about twelve years. It was first noted during attendance at college, while he was engaging in wrestling. It had been entirely asymptomatic and was never asso-

ciated with tenderness or ecchymosis. It had enlarged slightly. The swelling became prominent when he stood on his toes and on plantar



FIG. 6. Case iv. Multiple spontaneous muscle hernias prominent when standing on toes.

flexion of the foot. It disappeared on dorsiflexion of the foot, and when standing on the heels or with the leg elevated; it was reducible by pressure, revealing a circumscribed defect in the tibialis anticus fascia. Because of complete absence of symptoms, surgery was not advised.

CASE VII. A soldier, aged thirty-one years, had found two swellings on the left leg five years previous to examination while he was doing unusually heavy work loading box cars. Symptoms were absent except for unusual fatigability at the onset.

On examination there were three circumscribed swellings each about 1 cm. above the other on the anterolateral aspect of the mid-portion of the left leg about 3.5 cm. lateral to the crest of the tibia. They increased in size with plantar flexion or when standing on the toes, and disappeared when the leg was placed in the horizontal position or when the foot was dorsiflexed. With pressure, they were easily reduced and revealed a palpable defect in the fascia. Because of absence of symptoms, surgery was not considered.

CASE VIII. A soldier, aged thirty-eight years, had noticed two or three inconstant swellings on the left leg three years previously.

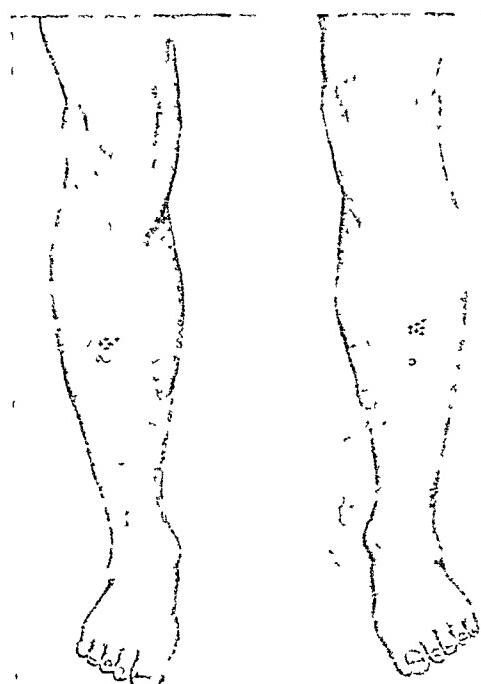


FIG. 7. Localization of muscle hernia in twelve patients observed by the authors: O, traumatic hernia; +, spontaneous or idiopathic type.

For about eight months they had been present constantly, slight soreness and aching appeared after walking or exercise. As a civilian he was a barber, but frequently engaged in hunting as a pastime.

On examination, two circumscribed swellings were present; one on the mid-left leg about 2 cm. lateral to the tibial border, and one on the lateral aspect of the leg just above the external malleolus. They increased in size when standing on the toes or with the foot in plantar flexion and disappeared with the leg in the horizontal position or dorsiflexion. With pressure, the swellings were easily reduced and fascial defects were palpable each about .6 cm. in diameter. Muscle hernias were diagnosed but surgery was not considered because of the minimal symptoms.

CASE IX. A soldier, aged twenty-six years, had discovered a swelling in the left leg five years previously while he was doing strenuous construction work. At first it was inconstant but since induction into the army, sixteen months previously, it had been present constantly. Moderate tenderness and pain were present, especially after running or fast walking.

On examination, a circumscribed swelling about .5 cm. in diameter was present along the lateral border of the left tibia at about its midpoint. It increased in size when standing on the toes and disappeared when standing on the heels or when the leg was in the horizontal position. It did not enlarge with either dorsiflexion or plantar flexion of the foot, probably because of its situation near the tibial border and the attachment of the muscle. Reduction was easily accomplished by pressure, revealing a defect in the fascia.

Muscle hernia was diagnosed, but surgery was not advised because of minimal symptoms.

**CASE X.** A soldier, aged twenty-one years, was unaware of any swellings in the legs and had no symptoms except cramping in the calves or feet after walking or exercise. He had never done any strenuous work prior to basic training at the time of induction.

On examination there were bilateral circumscribed swellings, on the right about one inch above and on the left about the same distance below the mid-leg, each about 2 cm. lateral to the tibial border. They increased in size with standing on the toes or plantar flexion of the foot; they disappeared when the leg was horizontal or dorsiflexed and with pressure, when defects could be palpated in the fascia. Bilateral muscle hernias were diagnosed but surgery was not advised because of absence of symptoms.

**CASE XI.** A soldier, aged twenty-two years, had a circumscribed swelling on the left leg for two years or longer without symptoms except increased fatigability of the left leg during basic training. He had participated in baseball and track. On examination there was a localized swelling about 1.5 cm. in diameter on the middle third of the left leg about 2 cm. lateral to the tibial border. It increased in size on standing on the toes and disappeared on standing on the heels. Surgery was not advised.

**CASE XII.** A soldier, aged twenty-nine years, had numerous and varied complaints typical of psychoneurosis. He had not been aware of any localized elevations in his legs.

On examination there were two localized swellings on the anterolateral aspect of the right leg, one about 1 cm. in diameter at the middle of the leg, and the other at the junction of the middle and lower third of the leg, about 2 cm. in diameter. They became prominent when he stood on his toes, and disappeared

when the leg was in the horizontal position or dorsiflexed. No treatment was advised.

#### ETIOLOGY

Muscle hernias occur predominantly in males, only one of the cases found in the literature being in the female,<sup>12</sup> due probably to the increased susceptibility of the male to injury and their greater muscular activity compared to the female.

With a few exceptions all the cases reported were observed in military personnel. However, in every instance in our series and in many instances in those reported in the literature when the duration is mentioned, the onset was in civilian life and they were diagnosed either only during routine military examinations or because of symptoms resulting from increased muscular use incident to military activities.

In our series, the ages varied between nineteen and thirty-eight years, corresponding roughly to the ages of the military personnel in whom they occurred. In the reported cases, the ages, when mentioned, were between nineteen and forty-two years.

They may be divided etiologically into the following types: (1) *Congenital*; (2) *traumatic*: (a) direct, due to direct injuries such as lacerations, operations, fractures, ulcers, gunshot wounds, or contusions; (b) indirect, due to acute muscle action; (3) *idiopathic or spontaneous*, probably due to: (a) muscle hyperdevelopment, (b) congenital weakness, or (c) increased muscular activity.

Actual congenital defects have been suggested by Lewis<sup>13</sup> and others as a possible etiologic factor, but we have not observed any and have been unable to find reports of cases in which the condition became apparent early enough in life to suggest this etiology. Localized congenital weakness may, however, be a predisposing factor in the production of the spontaneous type.

Direct trauma was responsible for the defect in eighteen of the 146 cases in which the etiology was given. Etiologic

trauma in our cases included a simple fracture, an ununited fracture treated surgically and an infected laceration by an axe. Those mentioned in the literature were lacerations, contusions, fractures, operations, ulcers, and penetrating foreign bodies such as bullets and hooks, all of which were traumas which produced a fascial defect either not repaired or which, when repaired, failed to heal because of supervening infection or for other reasons.

A small group arising as a result of trauma appears suddenly following a single, severe, indirect muscle strain which ruptures the overlying fascia and immediately results in hernia. Two such instances were observed by McWilliams<sup>14</sup> in participants in a game of "Irish Bowl." These developed herniation of the adductor longus muscle when strong adduction of the leg was suddenly and forcibly arrested during the course of the game.

The idiopathic group or those which develop insidiously without direct trauma, are relatively frequent, although of less clinical significance. One hundred twenty-eight of 146 cases in which the etiology was given belong to this group. They are observed usually in individuals who at some time preceding the onset engaged in strenuous activities, such as tennis, football, hunting, heavy lifting, or mountain climbing. Pichon, observed their occurrence in thirty-nine out of 217 Alpine soldiers. Congenital defects or weaknesses, particularly at the site of penetration of fascia by nerves or vessels, undoubtedly act as a predisposing and localizing factor as is suggested by their frequent symmetrical occurrence and the predilection of these hernias for certain positions in the leg, notably near the site of the emergence of blood vessels and the superficial peroneal nerve (Fig. 7) through the tibial fascia. Sherry in operating on these hernias, demonstrated the superficial peroneal nerve emerging through the fascia at the proximal portion of the hernial defect. Increased muscle volume, due to hypertrophy following increased muscular activity, was sug-

gested by Ihde as the activating etiologic factor. Their frequent observation in military personnel suggests that this factor, together with the strain of the increased activity itself, is of etiologic importance. Typhoid fever was also mentioned by Sherry as a possible etiologic factor; reports of such cases were not found.

#### SYMPTOMS AND FINDINGS

The clinical picture of muscle hernia is typically the presence of one or more circumscribed swellings which vary in size or disappear depending upon the position of the part involved and the state of contraction of the underlying muscle. There is associated pain and tenderness which is usually moderate to mild or may be entirely absent. They occur predominantly in males and may be situated on any portion of the body in which fascia overlies muscle tissue.

The condition has been reported in association with many of the more active muscles, among the most frequently mentioned being the tibialis anticus, biceps and triceps, adductors of the thigh, gastrocnemius, rectus abdominis, peroneus brevis, rectus femoris, vastus lateralis, and the muscles of the back.

In those due to direct trauma, there is a history of an injury such as a laceration, fracture, operation, gunshot wound, contusion, or ulceration. Repair of the original traumatic defect may not have been accomplished or if accomplished may have been complicated by infection and delayed healing. Immediately or some time after healing, the swelling appears with gradual enlargement until it attains its maximum size which may vary up to 5 or 6 or more cm. in diameter. It is semi-fluctuant, uniform in consistency and completely or partially disappears when the limb is placed in a horizontal position and usually when the involved muscle is contracted; it increases in size when the limb is dependent and usually when the involved muscle is relaxed. It is completely or partially reducible with pressure, reveal-

ing a palpable defect sharply outlined in the fascia through which the muscle protrudes.

The variation in size of the hernia does not invariably bear this constant relationship to the state of contraction of the underlying muscle, but varies depending upon its proximity to the attachments of the muscle, whether the underlying muscle is predominantly muscle tissue or tendon, and perhaps as Ihde suggested, upon its relation to the physiologic center of the muscle. In Case ix of the present series, the hernia was situated close to the tibial border and did not vary greatly in size with dorsi- and plantar flexion, probably because of its situation over the site of the muscle attachment at the tibial border. In Case iv likewise, there is less variation in size with dorsi- and plantar flexion of the foot but here the defect overlay the more tendinous portion of the muscle. When adhesions are present between the fascia and the muscle, variation in size may be less marked with change in position, and reduction may be incomplete with pressure; when there are adhesions between the muscle and the overlying skin, the latter moves visibly with contraction and relaxation of the muscle, and there may even be a dimpling or depression coincident with muscle contraction.

There may be no discomfort whatever or local aching of variable severity may be present, sometimes with radiation along the course of the muscle, aggravated by prolonged walking or strenuous exercise. Sometimes the discomfort may be severe enough to be disabling; cramping in the leg muscles is present in some instances. Tenderness is very slight or absent. Aspiration of the tumor yields negative results.

When the etiologic agent is indirect trauma, the patient gives a history of the immediate appearance of a painful tumor when strong contraction of the involved muscle is suddenly halted. Such a history is also typical of a muscle rupture but in the latter instance there is no palpable defect in the fascia.

Those hernias not due to trauma are typically smaller in size, varying from 3 mm. to 1 or 2 cm. in diameter. In some instances they are solitary, more often multiple or bilateral. As many as six were observed in one patient in our series and Kitchin and Richmond reported one patient who presented seventeen hernias.

The onset may be entirely unnoticed or there may be swellings which at first come and go, gradually becoming more persistent, especially after long standing or excessive walking. There may be no associated discomfort or there may be increased fatigability or a slight to moderate degree of local discomfort, leg pain or muscle cramping, always more marked after muscular exercise. Variations in size and reducibility are dependent upon the same factors which influence the hernias due to direct trauma.

#### DIAGNOSIS

The diagnosis of muscle hernias in the leg is not difficult if the condition is kept in mind when confronted with one or several semi-fluctuant swellings, associated with slight or moderate aching or increased fatigability. The swelling varies in size with position of the limb, and the state of contractility of the underlying muscle and reduction on pressure reveals a palpable fascial defect. Aspiration yields negative results.

#### DIFFERENTIAL DIAGNOSIS

Muscle hernia in the leg is most often mistaken for a varicosity and even after an unsuccessful aspiration it may go unrecognized. The smaller hernias and varicosities present similarities such as disappearance when the leg is horizontal and reappearance when the leg is vertical, as well as compressibility; but when a muscle hernia is compressed the edges of the fascial defect can usually be distinctly palpated, and the swelling disappears and reappears when the muscle involved is flexed and relaxed. Muscle hernias are

usually round and frequently solitary; and even when several exist, one above the other, they do not present the continuity or the discoloration of the overlying skin which characterize a varicose vein. Aspiration of blood from a varicosity is conclusive.

An arteriovenous aneurysm is characterized by a thrill and bruit, absence of the static changes characteristic of a muscle hernia, absence of changes in size with flexion and extension of the muscle, and finally, blood can be aspirated from the aneurysm.

Localized masses of varicosities and deep-seated angiomas usually present discoloration of the overlying skin, palpability of multiple vessels, the lack of changes in size with muscle contraction and relaxation and the lack of fascial defect found on compression when a hernia is reduced.

Muscle rupture or pseudohernia, presents a swelling which becomes prominent when the involved muscle is contracted and fascial defect is not palpable. The size of a muscle rupture does not diminish with the passive change in position of the leg from the vertical to the horizontal. The history of onset is similar to that of only one type of muscle hernia, namely, that due to indirect trauma or muscle action.

Lipomas, myomas, cysts, and other tumors may be confused with hernias when the involved muscle is not readily reducible because of adhesions. In the latter, however, there is at least partial disappearance when the leg is elevated to the horizontal and the fascial defect can still be palpated, beyond the borders of which the protruding muscle cannot be mobilized.

#### TREATMENT

When muscle hernias are not large or when asymptomatic, treatment is not indicated. Those which have symptoms not due to other causes, or are large or deforming, should be treated surgically

unless contraindicated by age or associated conditions.

The first step in any type of surgical repair consists of the careful exposure of the entire fascial defect, complete mobilization and reduction of the herniated muscle, careful denudation of the fascia well back from the edges of the defect and accurate hemostasis. The simplest surgical procedure is closure by overlapping and suture of the edges of the defect, preferably with cotton or silk suture. This type of repair is applicable when the defect is small and the laxity of the borders permits their ready approximation.

When the defect is large and the degree of laxity of the fascia surrounding the defect does not permit closure by simple approximation, some plastic procedure, usually some type of fascia transplant is necessary. A continuous or interrupted lateral incision in the fascia, preferably near the line of the fascial attachment where other hernias are not apt to occur, may permit a sufficient degree of mobilization of the fascial borders to accomplish overlapping and closure, or may reduce the width of a larger defect and simplify fascial repair. (Fig. 4.) Frequently because of the tautness of the fascia, such a procedure is ineffective or accomplishes only partial closure as noted by Hartzell and in our second case, and then repair is best accomplished by a fascial transplant (Fig. 2) or by repair with narrow strips of fascia woven in such a manner as to repair the defect. (Fig. 5.) More efficient coverage may be obtained by using multiple, interrupted, fine cotton or silk sutures not only to anchor the strips at their passage through the fascial borders but also to spread them out and attach them to each other. These fascial strips are conveniently obtained from the fascia lata either by using a fascia stripper (Masson<sup>15</sup>) or by direct excision, and may be threaded into any needle with a sufficiently large eye. Undue tension should be avoided; and when reduction is not readily accomplished due to excessive volume, a portion or all

of the muscle may be excised as was recommended by McWilliams and Ihde. Rarely when the muscle cannot be reduced and is herniated extensively, the entire muscle may be excised and the defect closed as was done by McWilliams in a case of hernia of the adductor of the thigh. The fascia and all exposed surfaces should be protected with warm saline applications as constantly as possible during the operation.

Elastic pressure dressings, with immobilization in a complete or partial cast is carried out for about fourteen days, and walking is permitted after twenty-one days.

One patient with bilateral hernia was treated by Schmier<sup>16</sup> with injection of sodium morrhuate. There was complete relief from symptoms and disappearance of hernia for one year, then recurrence which cleared up after a second series of injections. This type of treatment may be tried in the smaller type of hernia when surgery is not desirable and symptoms are mild.

#### PROGNOSIS

Muscle hernias of the leg usually enlarge primarily for a relatively short period of time and then remain stationary in size. The symptoms are usually mild or moderate; but when there is excessive marching or exercise, discomfort may be aggravated and at times severe. Complications are rare; adhesions may aggravate the symptoms, very rarely strangulation may occur, as in the case reported by Conwell and Alldridge.

Incarceration may occur and the hernia become non-reducible as in McWilliams' patient. Hemorrhage has rarely occurred preceding or coincident with the appearance of the hernia but has not been observed as a complication.

Recurrences after operation have been reported especially when an attempt has been made to approximate the edges under tension and when infection has occurred as a complication of operation.

#### SUMMARY

Twelve patients with muscle hernias of the leg are presented. Three had large, solitary hernias of the tibialis anticus muscle, all due to direct trauma and two of which had symptoms severe enough to justify surgical repair which was successfully accomplished by fascial transplant. Nine patients had multiple small hernias which developed spontaneously with possible congenital weakness as a predisposing factor in some.

The literature dealing with muscle hernias is comparatively scant. An incomplete review reveals 163 cases of muscle hernias of the leg reported, including the twelve in the present report.

#### CONCLUSIONS

1. Muscle hernias of the leg are not of infrequent occurrence, particularly in active young males as represented by soldiers; they are most often recognized when muscular activity is increased.

2. Hernias of muscle of the leg are characterized by a soft, semi-fluctuant swelling which increases in size when the limb is dependent or the muscle is relaxed and decreases in size or disappears when the leg is passively elevated and usually when the muscle involved is contracted. It is reducible on pressure when a distinct fascial defect can be palpated.

3. There are three types: those due presumably to congenital defects, none of which were observed; those due to direct trauma, as fractures, lacerations and operations or to indirect muscle violence. These are usually single, large, and produce symptoms for which surgery is indicated. Those of the third or idiopathic type appear spontaneously, particularly after muscular activity is increased. They are usually small, often multiple, present less severe or no symptoms, and frequently require no treatment. They are apparently quite frequent, especially among young, active males.

4. Differentiation between muscle hernias and varicosities is most often con-

fusing. Other conditions to be differentiated are localized varicose veins, lipoma, angioma, and other tumors.

5. Surgical treatment, when indicated, consists of reduction of the herniated muscle and repair of the defect, usually by fascia transplant or suture. The results are usually good.

6. The importance of careful repair of fascial defects arising from trauma or after operation, in order to prevent later development of hernia, is emphasized.

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# GREATER EFFICIENCY IN STEAM PRESSURE STERILIZATION OF SURGICAL SUPPLIES

THEODORE E. WADE, M.D.

PUEBLO, COLORADO

**A**TTENTION is called to some principles of physics and bacteriology. It is suggested that by taking greater advantage of some of these, the speed and accuracy of our surgical autoclaves may be increased.

Numerous investigators have worked to determine the amount of heat which must be applied to attain complete sterilization. Baking an object with dry heat at not less than 150°C. (300°F.) for a period of one hour is considered a reliable procedure for sterilizing the surface of an object (Zinsser and Bayne-Jones 1939). This, however, tends to destroy rubber goods and damages many fabrics. Penetration within wrapped bundles is unreliable. "Contact with ten pounds of saturated steam will probably kill all surgically significant spores within six minutes and should even destroy the highly resistant spores of *Clostridium botulinum* within 20 minutes. When the pressure of saturated steam is increased to 15 pounds, complete sterilization should be obtained in approximately one-third of the times mentioned above." (Hoyt, Chaney, and Cavell, 1938.) At sterilizing temperatures, liquid water itself seems to have antiseptic properties so that bacteria are destroyed more rapidly when they are wet. They may survive considerable exposure to similar temperature in the dry state. Superheated steam is of no more value as a sterilizing agent than hot air because it tends to dry the objects with which it comes in contact. (By the time it is cool enough to condense it has ceased to be superheated.)

The effect of dry heat on the non-sporulating bacteria was studied. A mixed suspension of *Streptococcus pyogenes* and of hemolytic *staphylococcus aureus*, which

had been recovered from infected wounds, was used to wet the inside of ten small glass test tubes. These were dried in the incubator and then sealed by fusing the open end in a flame. Three tubes were heated in an autoclave at 121°C. for twenty minutes and three for forty minutes. Four tubes were used as controls without heating. Both organisms were recovered from each of the tubes. When wet these organisms are killed within one minute at that temperature. This emphasizes the importance of moisture in sterilization.

Spores of *Clostridium oedematiens* are considered by a number of observers to be the most heat resistant of any of the organisms of surgical importance (Hoyt, 1934). Previous drying does not appear to increase the resistance of bacterial spores to the action of heat in the presence of saturated steam (Esty and Meyer, 1922). The following thermal death times were determined for direct contact with saturated steam by Hoyt, Chaney, and Cavell (1938).

	Cl. Botulinum A., Minutes	Cl. oedematiens, Minutes
6 pounds saturated steam, 110°...	Over 30	10
10 pounds saturated steam, 115°...	10	4
15 pounds saturated steam, 121°...	4	1

These observations and findings indicate that the most resistant spores of the known pathogenic bacteria are destroyed by exposure to moist steam at a temperature of 121°C. (250°F.) for periods of one to four minutes. If all pathogenic bacteria can be destroyed in less than five minutes, and

probably within one minute, what is to be gained by applying the sterilizing agent for a longer time? Doubling this time to ten minutes should provide more than 100 per cent margin of safety if it were certain that every spore had received the full treatment. The only excuse for any time longer than this is to provide time to allow the sterilizing agent to penetrate to the most hidden bacterium to a degree which will be effective. If diffusion and convection are depended upon to secure penetration of steam to the innermost folds of a large pack of sheets, prolonged periods of sixty to ninety minutes may be required to assure sterilization. A method of assuring that pure saturated steam under pressure is promptly applied to the most remote surface within the material to be sterilized should greatly shorten the time needed to produce complete sterilization.

The method whereby an object being sterilized attains sterilizing temperature is worthy of consideration. In a space occupied entirely by steam, the total gas pressure and the water vapor pressure are identical. At a water vapor pressure of thirty pounds per square inch (representing pure steam with fifteen pounds gauge pressure where atmospheric pressure is fifteen pounds) the temperature cannot be less than 121°C. (250°F).

Any object in this atmosphere which has a temperature less than 121°C. will absorb heat from the steam which rapidly condenses upon its surface until it has attained a temperature of 121°C. During this process of vapor condensation, the pressure upon the surface of the object will tend to be lowered. Steam from the surrounding space will flow toward the object. The process of condensation will continue, and the temperature of the object will rise until an equilibrium of temperature and pressure has been re-established. If the atmosphere in the chamber is composed partially of steam and partially of air, condensation of steam upon the surface of the cold object will cause a similar tendency for its temperature to be raised and for the surrounding

gases to flow toward the object. However, as this process continues, the ratio of air to steam in the immediate vicinity of the object will be greatly increased. This increase will be due to the fact that the steam will condense upon the surface and trickle away as water, whereas the air which approaches the object with the steam cannot be condensed and will tend to form a blanket of air upon its surface. For this reason heavy objects which have considerable thermal inertia should be exposed to the steam in the chamber, without cover, so that convection can dissipate this air blanket, which might otherwise be held in the meshes of the surrounding fabric. Air tends to accumulate toward the center of a pack in an autoclave in an atmosphere of part air and part steam, especially in the case of a large pack of tightly folded linen. This is partly because of the fact that steam is absorbed as water by the cold linen, leaving the air to occupy the space between the fibers of the fabric. To overcome this difficulty and assure adequate sterilization of all fibers within the pack, either of two courses may be followed. Much time may be allowed in the hope that by diffusion steam will find its way to the center and that by conduction sufficient heat will penetrate to the center of the pack. This method of hopeful waiting involves much uncertainty and a considerable margin of time must be allowed for safety's sake.

The alternative course is actually to remove the air forcibly from the pack and replace it with steam, maintain that steam at a known pressure for a known length of time, and then terminate the sterilizing procedure with confidence that sterilization is complete. By elimination of guess work as to when the innermost part of the pack reaches sterilizing temperature, those long periods of hopeful waiting are eliminated, saving much damage to linen and other goods being sterilized.

The sterilization of rubber gloves presents a problem of its own. The sterilization of the inner surface of a rubber glove is

equally as important as the sterilization of the exterior because of the possibility of tearing of the glove while it is being used. Rubber deteriorates during long exposure to sterilizing temperatures. Gloves are powdered inside and out to prevent adhesion between the surfaces in contact. The powder and residual air within the glove tend to absorb moisture. The glove is heated by steam in contact with its exterior surface in much the same way that the wall of the autoclave chamber is heated by the jacket, thereby preventing precipitation of moisture upon the interior of the glove. Rapid autoclave sterilization is dependent upon contact with saturated steam. If permeating by steam of the entire space within a rubber glove is dependent upon convection and diffusion, it is possible that the space within the finger of a powdered glove may sometimes fail to become moist. Therefore, it becomes obvious that the sterilization of the interior of a glove is a more positive procedure and the length of exposure required for complete sterilization is reduced when steps have been taken actually to remove the air from the glove and to replace it with steam.

Hypodermic needles are frequently placed in glass tubes for sterilization. If the end of the tube is occluded by a rubber or other impervious stopper, sterilization of the needle in an autoclave cannot reliably be accomplished, because the interior of the tube would remain dry even though it attained sterilizing temperature. Closing the end of the tube with a porous cotton plug permits air to leave the tube and steam to enter it. Active replacement of air by steam within the tube insures prompt and thorough sterilization.

The sterilization of solutions within the autoclave presents a still different problem. Heat is transmitted to a solution through a metal wall very effectively and rapidly. A vessel with a thin glass wall will permit fairly rapid heating of its contents. Because glass is a poor conductive medium, the heavier the walls of a glass vessel the more slowly the heat will reach the liquid within.

No advantage is believed to be gained by pressure changes in the heating of solutions. The pressure must be reduced very slowly after sterilization of liquids to minimize foaming and loss of solution by boiling over.

The preparation of vaseline gauze for wound dressing requires special consideration. Lang and Dean (1934) found that "Destruction of spores by heat in an oil medium may be said to embrace conditions existing in dry heat sterilization." They found that oil coated spores which had been heated for periods much exceeding that required to kill the spores exposed to moisture, were still viable when the oil was removed. It is, therefore, obvious that the only safe procedure is to sterilize the gauze and its container with steam, and then add vaseline or petrolatum to be melted into the sterile gauze by subsequent heating. This requires, in addition, that the petrolatum be handled in such a way as to avoid bacterial contamination, from the time it is prepared at the refinery until it is used in the surgical dressing room. Petrolatum which has been much handled, as by rubbing boric acid or other matter into it, does not seem to fulfill these specifications. Methods for sterilizing such mixtures after preparation have not come to my attention. In practice vaseline causes almost no trouble although its preparation rarely meets these standards. This may be due to an enveloping action of the vaseline which may prevent bacteria in the gauze from reaching the wound surface. The matter deserves attention.

Sterilizing of uncovered solid objects, such as instruments upon an open tray, is accomplished rapidly and effectively by simple exposure to saturated steam under pressure. They contain no air to be displaced.

The principle of exchanging air for steam in the autoclave chamber may be described as follows: The outer jacket of the autoclave is heated with steam under pressure, the charge is placed in this autoclave and the door closed. Steam is ad-

mitted to the chamber. The steam entering the chamber strikes against a baffle which causes it to spread in a layer occupying the top portion of the chamber. Steam is lighter than the cooler air which previously occupied the chamber. As the steam continues to enter the chamber the layer of steam becomes progressively deeper pushing the air downward. The air escapes freely through the drain at the bottom of the chamber until live steam begins coming through the drain and closes the automatic drainage valve. At this original filling of the chamber with steam probably more than 95 per cent, of the air in the chamber is replaced by steam and some air may continue to work its way to the drainage valve during the sterilization process. Maintaining two distinct layers of gas within the chamber, while the air is being displaced, depends upon the steam being lighter than air. Therefore, it is best to charge the sterilizer with steam immediately after closing the door before the air within the sterilizer has had time to absorb heat from the walls of the chamber. Thus, in a modern autoclave, air is quickly and effectively evacuated from the sterilizing chamber itself.

The positive application of saturated steam to all surfaces within a pack, closed drum, rubber glove, or glass tube is not reliably accomplished by the method of gravity displacement previously described for an open autoclave chamber. Rather, it is safer actually to remove the air and replace it with steam. A step-by-step description of this procedure for the removal of air follows: The air in the chamber about the object to be sterilized is replaced with steam at the original filling of the autoclave chamber. Some steam will penetrate the object by gravity and diffusion, but this will be disregarded because of the lack of certainty with which it occurs.

1. If the pressure of the steam in the chamber is increased to fifteen pounds (gauge), the steam will have an absolute pressure of approximately two atmospheres. At this time the air within the

object will have been compressed to half its volume so that steam will occupy half the gas space within the object. A considerable amount of diffusion and mixture of steam and air will occur in the area of contact between the steam and air. Some water will have condensed upon the surfaces exposed to the steam.

2. Steam is allowed to escape from the chamber until the gauge pressure reaches 0. During this time half the content of air and steam within the object will have escaped from the object by expansion.

3. The pressure within the chamber is further reduced by the use of the vacuum device to one-half atmosphere (minus 15) inches of mercury. At this point about one-half of the steam air mixture which was in the object at 0 pressure has been removed by further expansion. During these expansions a part of the moisture which had condensed upon the surfaces within the object evaporates. This evaporation tends to follow the reduction of pressure so the water vapor, thereby produced within the object, tends further to flush the air from the spaces within the object. It will be noted that one-fourth (i.e., one-half of one-half) of the original air content of the object remains within the object at this time. (Because diffusion in the mixture of steam with air could not have been complete, the amount of the remainder of air must be considered approximate.)

4. Steam is now admitted to the chamber until the gauge pressure reaches fifteen pounds. It will be remembered that about one-fourth of the original content of air may be still in the pack.

5. If gas is again exhausted from the chamber to one-half atmosphere of pressure (minus 15 inches of vacuum) in a manner identical with that described in (2) and (3) above, three-fourths of the air remaining within the chamber is again removed. This leaves one-sixteenth of the original content of air.

6. The chamber is again filled with steam to fifteen pounds (gauge) pressure

and then evacuated to a pressure of minus 15 inches of mercury, this time leaving one-sixty-fourth of the original content of air within the package.

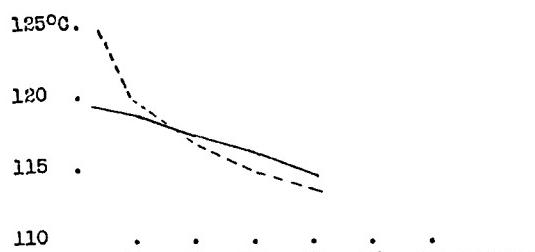


FIG. 1. Minutes required to cause complete change of color and/or melting of sterilizer control device at various temperatures. Solid line for "Diack" controls; broken line for "Sterilometers."

7. This change of pressure is repeated more times for larger, denser packs.

8. Steam is admitted to the chamber till a sterilizing pressure of fifteen or twenty pounds is obtained, where it is held for a period of ten minutes.

Simple devices which change color or shape at a known temperature have been commonly accepted as indicating whether sterilizing conditions have prevailed. The time required to effect two such sterilization control devices was determined by watching the temperature of the discharge pipe during exposure to steam in the autoclave. The results are shown on the accompanying graph. About seventy-five tests were made. Some variation in the individual controls was found. The end-point of "Diack" melting was found to vary from 113°C. to 119°C. for exposures of ten minutes. In one instance, six "Diack controls" were heated simultaneously in one loose cluster at 115°C. for fifteen minutes; one was melted, three were incompletely melted, and two showed no change. Greater constancy was found in the "Sterilometers." Both "sterilizer control" devices were subjected to repeated rapid alternations of steam pressure and vacuum without effect on their color or shape. It is assumed that each of these devices is a valuable and reliable aid in determining

whether sterilizing temperature has been attained in the autoclave.

The following experiments demonstrate the effectiveness of alternation of steam pressure and vacuum in pumping residual air from even the most dense, tightly packed bundles of fabric, thereby attaining more rapid heat penetration.

*Experiment No. 1.* Eleven folded hospital sheets were rolled very tightly, making a dense bundle 20 cm. (8 in.) in diameter by 40 cm. (16 in.) in length. This was wrapped with paper. To melt "Diack" controls regularly in the center of such a roll by the conventional method of autoclaving required more than forty-five minutes exposure to steam at 121°C. In similar rolls, emptied of air\* and then exposed to steam at 121°C., "Diack" controls were always melted within ten minutes. Spores of Clostridium botulinum were suspended in Thioglycolate culture broth and sealed in glass ampoules. These were wrapped in rolls identical with those described above. After removal of air,\* one roll was exposed to steam at 121°C. for each of the following times: ten, seven and one-half, five, and three minutes. The ampoules were then incubated. No growth occurred in any of them, surprisingly not even in the one exposed for only three minutes. Other ampoules prepared in the same lot, but not subjected to autoclaving all produced Clostridium botulinum by incubation.

*Experiment No. 2.* A conventional sterilizing drum 25 cm. in diameter with side ports which can be slid open or closed was tested. Folded sheets were rolled very tightly and bound with string so that they formed a bundle which completely filled the drum from the bottom to the lid, and which required effort to force it into the drum. "Diack controls" were placed within this roll at intervals of 2 cm. from the circumference to the center. When

\* In this group of tests air was evacuated by four pressure changes. Each change was from two atmospheres (fifteen pounds steam pressure) to one-half atmosphere (fifteen inches of mercury vacuum).

such a package was placed in the sterilizer with the lid raised about 2 cm. and the side ports opened, it was immediately auto-

Another drum prepared in an identical manner was placed in the autoclave with all ports and the lid closed. It was treated

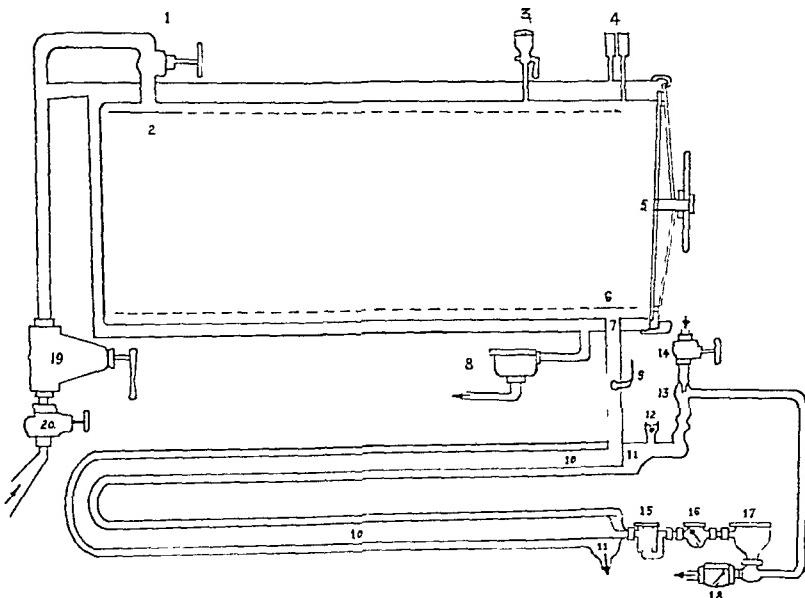


FIG. 2. Suggested modification of autoclave to facilitate rapid displacement of air.

For an autoclave with a chamber capacity of 5,000 cu. in. (100 liters) the supply pipe should not have less than  $\frac{5}{8}$  inch (15 mm.) inside diameter. The pipe for evacuating the chamber should be 1 inch (25 mm.). "Bend" fittings should be used in lieu of L's to avoid sharp turns in these steam pipes. Liquid on the floor of the chamber should flow by gravity to outlet No. 7. 1, Steam inlet valve; 2, baffle to cause steam to form a layer in top of chamber, thus minimizing mixture with air while the cold air is being blown out; 3, cotton filtered air inlet valve to permit opening door after sterilization is complete; 4, gauges indicating jacket and chamber pressures; 5, a conventional lever-locking autoclave door; 6, baffle in floor of chamber to prevent objects within the chamber from blocking the free exit of air; 7, large unobstructed outlet opening; 8, automatic valve which permits escape of cold air and water from the jacket but closes when heated by live steam; 9, thermometer which indicates the temperature of gases being discharged from the chamber which are usually the coolest gases within the chamber; 10, inner condenser tube, "U" shaped to permit expansion and contraction without breaking the joints at the ends of the water jacket; 11, water-cooled condenser jacket so arranged that the jacket is drained completely by gravity except while suction pump is operating; thus, the air in the empty condenser jacket acts to insulate its inner tube during the sterilizing period; 12, overflow device permitting escape of air; 13, water jet type suction pump; 14, valve to control suction pump; 15, screen to catch fibers which might clog the automatic valves; 16, check valve; 17, automatic valve which permits escape of cold air and water from the chamber but closes when heated by live steam; 18, check valve; 19, automatic pressure regulating valve to maintain constant pressure on steam supply line; 20, valve on main steam line; 21, safety valve, not shown in the diagram, at any point on jacket or supply line following the pressure regulator.

claved with a discharge temperature of 122°C. (252°F.) for forty-five minutes; wax in the controls was melted only to a depth of about 6 cm. The center of the drum had not attained a sterilizing temperature.

by four pressure changes, following which steam pressure with a temperature of 122°C. (252°F.) was maintained for ten minutes. The contents of this drum were examined and all Diack controls were

found to be melted, including one at the center of the pack.

*Experiment No. 3.* An empty metal "lard" can, 45 cm. (18 in.) in diameter and 80 cm. (32 in.) in length, was tightly packed with muslin and the metal cover was fastened in place by tying it on with cord. Diack temperature indicators were inserted into the pack every 5 cm. from the top to the bottom. When completely packed and covered, the only remaining opening was the little crack between the lid and the end of the can, which averaged less than 1 mm. in width. The loaded and covered can was placed in the autoclave on its side and steam was alternately forced into and withdrawn from the can making four complete pressure changes, as rapidly as our equipment would permit, after which a temperature of 121°C. (250°F.) was maintained for ten minutes. The can was then removed from the sterilizer and its contents examined. The wax in each Diack tube was found to be melted, indicating that sterilizing temperature had been attained at the most inaccessible points within the can.

*Experiment No. 4.* One large heavy canvas linen conveyor bag which fully occupied the space within the chamber, 160 cm. long by 50 cm. in diameter, was placed in the autoclave and packed tightly with linen. Diack's sterilization controls

were placed at regular intervals throughout this mass of linen to test the temperature attained at various depths and levels. The purse string closing the end of the bag was drawn closely leaving one opening about 10 cm. in diameter just inside the sterilizer door. The autoclave was filled with steam, four pressure changes were made to evacuate air from the bag and its contents, and steam pressure was maintained at a temperature of 122°C. (252°F.) for ten minutes. The bag was removed from the sterilizer and its contents examined for heat penetration and moisture. The wax in each of the Diack "controls" was found to be melted. Faint moisture was present in the layers of the fabric at all levels throughout the bag. This bag was re-packed in a similar manner and was subjected to one continuous exposure to steam for a total length of time equal to that required for the pumping out of air plus the sterilizing period. During this exposure about half the "Diacks" failed to melt.

#### DIRECTION FOR OPERATION OF AUTOCLAVE

1. Begin with all valves closed.
2. Open valve 20.
3. Set valve 19 to maintain desired pressure.
4. Place charge in chamber and close door 5.

TABLE OF SUGGESTED STERILIZATION TECHNIC

Dressings in very large dense packs	4 changes* plus 10 minutes†
Dressings in normal size packs in double muslin covers	2 changes plus 10 minutes
Fully loaded drums with double muslin liners	4 changes plus 10 minutes
Utensils, nested, in double muslin covers	4 changes plus 10 minutes
Utensils, single, in double muslin covers	2 changes plus 10 minutes
Instruments without cover held high in chamber	Direct exposure, 126°C. (260°F.) 5 minutes
Instruments in trays without cover	Direct exposure 121°C. for 10 minutes
Instruments wrapped for storage	2 changes plus 10 minutes
Rubber gloves in double muslin wrappers, not stacked	2 changes plus 10 minutes
Transfusion or intravenous sets or catheter trays	2 changes plus 10 minutes
Solution (1,000 cc. bottles or Baxter or Cutter Safti-flasks)	Direct exposure‡ for 20 minutes
Solutions (1,000-1,500 cc. flasks) (thin glass)	Direct exposure‡ for 15 minutes
Solutions (500 cc. flasks) (thin glass)	Direct exposure‡ for 12 minutes
Solutions (25-250 cc. flasks) (thin glass)	Direct exposure‡ for 10 minutes

\* Each change represents evacuation of chamber from a gauge pressure of fifteen pounds or more to minus 15 inches of mercury vacuum and then refilling to fifteen pounds pressure with steam.

† "plus 10 minutes" means that the material to be sterilized will be subjected to steam at a temperature of 121°C. (250°F.) or more for ten minutes after the last change.

‡ Direct exposure, to saturated steam at a temperature of 121°C. with no alternation of pressure and vacuum before sterilization and slow reduction of pressure afterward.

5. Open valve 1. Watch until pressure within chamber ceases to rise, i.e., until hand of pressure gauge stops.\*

6. Close valve 1 and open valve 14. Watch until pressure seems to cease to fall.

7. Close valve 14 and open valve 1. Wait until chamber is filled (i.e., until gauge can no longer be seen to move.)†

8. One complete pressure change has been accomplished. Steps 6 and 7 are repeated alternately and rapidly until the required number of pressure changes have been made.

9. After last pressure change allow valve 1 to remain open ten minutes.

10. Close 1 and open 14 and allow contents to dry as desired.

11. Close 14 and open valve 3 to admit air and allow door to be opened.

#### CONCLUSION

1. One to four minutes exposure to saturated steam at a temperature of 121°C. (250°F.) should destroy all pathogenic bacteria. Ten minutes such exposure should provide a liberal margin of safety.

2. Such exposure can be assured only by rapid thorough removal of air *before* expo-

\* This sterilizing procedure can be performed with any modern surgical autoclave. The autoclave described above has been designed to reduce the time required for filling and emptying the chamber, viz., steps 6 and 7 above.

† If using a rapidly filling and emptying autoclave, hold this pressure for fifteen seconds for muslin wrapped packs and up to ninety seconds for very large dense packs with nearly impervious covers. It is more efficient to make an extra change of gas (steam) than to waste many minutes waiting for a slow autoclave to gain that last pound of pressure.

sure, thus permitting steam to reach every spore without delay. A method of removing air is discussed.

3. It is suggested that the common sterilizing room procedure, of hopefully waiting for air to be removed from the sterilizer contents by diffusion and by gravity, wastes time and is often ineffective.

4. It is believed that if very difficult objects can be penetrated and sterilized by this method, surely the usual type of surgical goods can certainly be rendered sterile by the same method.

5. This method of sterilization can be performed with any autoclave which is equipped with a vacuum device. If the autoclave can be rapidly filled and emptied, this method will save much time in the sterilization of supplies. It will materially reduce the deterioration of rubber and other goods being sterilized. Further study may show that the sterilizing period can be shortened even more.

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# THE HANDLING OF WAR CASUALTIES

JOSEPH K. NARAT, M.D.

On Senior Surgical Staff, St. Elizabeth Hospital

CHICAGO, ILLINOIS

**T**WO factors detract from the value of reports on surgical experience in the first World War: changed methods of warfare which create new types of injuries, and the continuous progress of surgery responsible for modifications of old or introduction of new therapeutic measures. However, such reports are of great interest, first, because certain fundamental principles remain unchanged and, second, because an accumulation of data collected from personal experiences may pave the way to improvements in the treatment of war casualties.

It is in this spirit that the following report, based on four years' experience in field clearing stations and mobile evacuation hospitals is submitted, with the hope that the suggestions offered may be accepted as such or may lead to new developments.

It can not be too strongly emphasized, that the suggested therapeutic measures should not replace but rather supplement newer methods which had time enough to demonstrate their merits.

Naturally, no attempt has been made to cover the entire field of traumatic surgery, attention being paid chiefly to subjects infrequently mentioned in the literature.

## CHEST INJURIES

Five complications deserve attention: hemothorax, tension pneumothorax, open pneumothorax, mediastinal emphysema and concomitant injury of abdominal organs.

In patients who show signs of a grave anemia, a reinfusion of the blood evacuated from the chest cavity may be considered, especially if no donor's blood or plasma is available. The danger of injecting a

coagulum is minimal because the blood accumulating in the pleural cavity remains liquid. Three theories have been advanced to explain this phenomenon: (1) The pleural serosa is identical with the endothelium of blood vessels which maintains the blood in the liquid form. Anatomists disagree with this theory. (2) Respiratory movements of the diaphragm agitate the blood and desirbrate it. This theory does not explain the fact that blood remains liquid in injured articulations. (3) The pleural lining secretes an anticoagulating substance. This hypothesis has a great appeal although it has not yet been proved. As to the danger of contamination, experience shows it to be of no great importance if the customary precautions are taken.

A tension pneumothorax is usually caused by a valved opening in the lung which permits the entrance of air into the pleural cavity but not its exit. A thoracocentesis should be performed and a drain equipped with a perforated condom introduced.

If an open pneumothorax is caused by an extensive laceration of the thoracic wall, a prompt closure of the defect is essential to eliminate the respiratory embarrassment and the disastrous effect of mediastinal flutter. When approximation of the rib above and the rib below is not sufficient to cover the defect, the open, sucking wound may be closed with elasto-plast, which, however, is usually not available in the combat zone. It was found that a very efficient occlusive dressing can be made from wax paper, salvaged from cartons containing x-ray films. Such paper can be collected from x-ray stations and kept in readiness at more advanced field stations. In emergency anything may be used to plug the opening, even with a

disregard for sterility. Dressings applied to the wound are apt to move and usually do not produce a sufficient occlusion. A more efficient way is to employ a dressing resembling the old Mikulicz pack: The center of a towel is introduced into the thoracic cavity and the bag created in this manner is stuffed with sponges or any other material available. The resulting dressing resembles a mushroom and is not easily expelled. The patient should be placed on the injured side in order to obtain pressure and to facilitate drainage as well as respirations on the normal side.

Mediastinal emphysema may result from an injury of the trachea or larger bronchi; occasionally it may be produced by a rupture of the lung underneath an intact visceral pleura. Tension pneumothorax may also be responsible for the same condition, recognizable by dyspnea, cyanosis, crepitation above the manubrium, dilatation of cervical veins and facial edema. X-ray findings are also characteristic. The condition calls for a short incision in the suprasternal notch, carried through the skin and platysma, and followed by a blunt dissection with the finger until the mediastinum is reached.

#### ABDOMEN

An abdominal injury may erroneously be diagnosed while in reality an injury to the intercostal nerves is responsible for abdominal pain. This type of injury may also cause tenderness, muscular rigidity and leukocytosis. Therefore, the inspection should not be limited to the abdomen, but the chest should be examined in every patient with pains in the abdominal region. As a rule, the rigidity is unilateral and there is no vomiting; furthermore, when a relaxation of abdominal muscles is produced by placing the patient on a backrest, the rigidity disappears within a short time. Conversely, presence of bile or gastrointestinal contents in fluid aspirated from the pleural cavity indicates

an abdominal, or, more correctly, an abdominothoracic injury involving a hollow viscus.

It should be remembered that spinal injuries may produce referred abdominal pain and rigidity. No diagnosis of a contusion of the abdomen should be made without a thorough examination of the patient, including the chest and the spine.

Small perforations of the intestines should be sutured while an enterostomy is indicated in more extensive injuries. Resection should be undertaken only in presence of extensive destruction or numerous perforations of intestinal loops, or segments devitalized by an injury of the mesentery. The surgeon may be inclined to eviscerate the abdomen in order to minimize the spilling of the gastrointestinal contents into the peritoneal cavity, but it should be remembered that patients with abdominal injuries stand the eventration poorly. For this reason inspected segments of the intestines should be immediately replaced into the peritoneal cavity before the search is continued.

Appendicitis can be simulated by a traumatic hematoma in the abdominal wall, caused by a contusion. Vice versa, the fact should be kept in mind that a patient who sustained a contusion of the abdomen may concurrently develop appendicitis which can be easily overlooked if the surgeon's thought is focused upon trauma only.

#### INJURIES OF THE THIGH

Injuries of the upper third of the thigh are less dangerous than injuries of the lower two-thirds because the bone lies relatively close to the surface and is therefore easily accessible. The hematoma which forms after an injury of the bone has a tendency to infection and formation of an abscess which spreads along the quadratus femoris and adductor minimus muscles or follows the course of the ileopsoas muscle. To avoid this complication and to release the interstitial tension which may interfere with the blood supply, it is advisable to

make a 10 to 15 cm. long incision on the lateral aspect of the thigh in order to evacuate the hematoma.

As a rule, injuries of the middle third of the thigh are much more serious because blood vessels located closely to the bone are exposed to an injury by bone fragments and because the bulky muscles are an easy prey to infection. For the aforementioned reasons a prophylactic incision on the lateral aspect of the thigh is indicated. No counterincision in the femoral trigonum should be made because the proximity of large blood vessels creates a danger of a secondary hemorrhage by arrosion.

In complete fracture of the lower third of the femur the lower fragment is usually tilted backward by the gastrocnemius muscle. If the extremity is placed on a straight splint, the traction of this muscle increases the posterior dislocation of the distal fragment of the femur, with a resulting danger of an injury of the femoral artery. To avoid this danger, the splint should be applied with the knee not in extension, but a flexion of about 135 degrees. Formation of an abscess in the popliteal space may be prevented by incisions on the medial and lateral sides of the thigh.

Such prophylactic measures are justified in view of the fact that at least 75 per cent of injuries of the femur under war conditions become infected.

It remains to be seen whether an early administration of sulfa drugs will prevent the occurrence of infections to such an extent that prophylactic incisions for evacuation of hematomas will prove superfluous.

In regard to amputations, adverse criticism is anticipated concerning the unorthodox preference of flaps to a guillotine amputation. Nevertheless, formation of flaps offers the great advantage of saving more tissues. One point cannot be stressed too much, namely, that the flaps should not be sutured.

Flexion and abduction contractures, frequently following an amputation of the thigh, interfere with walking. There-

fore, the elevation of the stump and flexion to 45 degrees after the operation should be abandoned as soon as possible. Contractures can be counteracted to a great extent by placing the patient on his abdomen at frequent intervals. If a contracture developed and cannot be corrected by active or passive motions, an oblique incision through the gluteus medius, fascia lata and the iliobial tract will elongate the shrunken tissues. After this operation both thighs should be approximated by a heavy canvas binder placed around the hips.

#### GAS GANGRENE

An early diagnostic sign is the dissociation of pulse and temperature, the pulse being rapid out of proportion.

The impairment of circulation is due to two factors: (1) compression of blood vessels by toxic edema underneath the tense aponeurosis, and (2) stimulation of terminal branches of vasoconstrictor fibers in the blood vessel walls by toxic products.

To eliminate the mechanical factor of compression and to drain the edematous fluid, longitudinal incisions are made through the sheaths surrounding blood vessels and nerves. For instance, the sheath of the femoral artery can be opened in Hunter's canal and that of the posterior tibial artery behind the internal malleous. In addition to it, overlapping transverse incisions above the edematous area limit diffusion. To avoid pressure necrosis, wide strips of gauze placed around bundles of muscles can be attached to a wire type splint. Such separation of muscles keeps the wound open.

As to vasomotor reflexes, they can be suppressed by novocaine injections in suitable places such as Scarpa's triangle or the axilla. Intramuscular injections of 0.001 mg. of eserine sulfate diminish the tonus of sympathetic nerves.

A slow intravenous injection of gas gangrene serum, preceded by a subcutaneous adrenalin injection, is a heroic measure, to be used in grave cases.

It goes without saying that all these measures should be supplemented by the customary modern treatment of gas gangrene.

*Bacillus coli*, *proteus* and several non-pathogenic anaerobic bacteria may produce gas in phlegmomes or abscesses which are much more benign than gas gangrene and do not require radical treatment awarded the latter.

It is worth while remembering that tetanus and gas gangrene bacilli may remain dormant around foreign bodies a long time and that the infection may flare up following the attempt to remove them. It is wise to administer serum before the operation, no matter how much time elapsed since the injury.

#### GANGRENE

It is noteworthy that typhus is a factor predisposing to gangrene of lower extremities. Probably the exanthematic typhus has a toxic effect on vasomotor centers. If the outside temperature is low, patients with typhus should be watched closely; if the pulse of the dorsalis pedis artery is weak, a heat cradle should be applied, because the cold weather, with the typhus as a contributing factor, may produce a vasoconstriction sufficient to cause gangrene.

#### KNEE INJURIES

An infection following a knee injury may be confined to the upper recessus. In such case a rubber drain may be introduced posteriorly and the articulation filled with a 0.5 per cent novocaine solution to which 2 cc. of Chlumsky's solution (acid. carbol. liq. 30.0, camphor. 60.0, alcoh. absol. 10.0) has been added. The drain is plugged with a cork and the injured extremity splinted. The solution is changed daily. An empyema developing in the lower posterior recessus is a much more serious condition because the intra-articular ligamentary apparatus is easily involved and the edema spreads to the upper and lower leg. If the trauma is

not very extensive and the intra-articular ligamentary apparatus is still preserved, a resection of the articulation may be replaced by a more conservative procedure, namely, a resection of the condyles through separate incisions at their base, supplemented by an anterior arthrotomy. In this manner satisfactory drainage is obtained, the ligamentary apparatus is preserved and no shortening of the extremity follows the operation. Drains are inserted and the leg is placed in a body cast.

An extensive injury requires a partial resection of the articulation. A high temperature following the resection and persisting two or three weeks, but without any other signs of septicemia, is not an indication for an amputation. On the other hand, the continuation of a septic condition, lack of appetite and persistence of pains call for an amputation within one week after the resection.

#### COLD EXPOSURE

According to the degree of chilling and moisture, various terms have been applied such as immersion foot, trench foot, frostbite, etc., although the underlying condition is the same.

No oil or any other grease should be applied to leather shoes because it increases the conductivity of leather. Wrapping the feet into few layers of newspaper, before they are placed into the shoes, is a good prophylactic measure.

The mechanism of edema may be explained in the following manner: Prolonged exposure to intensive cold causes a reflex vasoconstriction with a resulting ischemia which in turn is followed by a local anoxemia. The interference with the cellular metabolism leads to an accumulation of carbon dioxide and lactic acid in the tissues. The shift of the hydrogen ion concentration to the acid side causes changes in the osmotic conditions in the tissues which, together with increased permeability of capillaries, produces edema. Furthermore, the abnormal acidity and changes in the osmotic

pressure lead to changes in the electric potentials of plasma proteins in the blood, facilitating agglutination and thrombus formation in the capillaries and veins. In addition to the disturbances of the acid-base equilibrium, the retardation of the blood current contributes to formation of thrombi in the capillaries and venules.

As to the treatment, the popular method of rubbing the frozen parts with snow carries the danger of secondary infection. A gentle kneading of the adjoining, not frozen parts through soft cloths is preferable. The frozen parts may be placed in water 6° to 10°C. (42.8° to 50.0°F.) gradually increasing the temperature to 15°C. (59.0°F.) It is advantageous to apply external and internal heat as soon as possible to the rest of the body.

A rapid application of heat to the frozen part is harmful because it causes vaso-paralysis, with a resulting stasis and transudation of plasma.

Among supportive measures, intravenous injections of papaverine or amino-phylline deserve attention because they have a vasodilating effect. Conduction anesthesia with novocaine without ad-

renalin also may be tried because it stops pain and suppresses the action of the autonomic nerves, thus inducing vaso-dilatation. For the same purpose paravertebral novocaine injection may be given. Rectal instillation of 5 per cent glucose solution with addition of alcohol is indicated in severe cases.

Wet ulcers were found to be healing quicker after application of gentian violet in powder form than after the employment of any other method of treatment.

#### NERVE AND TENDON INJURIES

No attempt should be made to suture injured nerves or tendons in contaminated areas. Everybody familiar with traumatic surgery knows the difficulty of finding the severed ends of nerves or tendons in old scars. To facilitate this task at the subsequent operation, a simple expedient of transfixing the proximal and distal portions of the injured structures with black silk is highly recommended. The sutures are left long, protruding through the wound, or can be carried through the margins of the skin.



# Case Reports

## TOTAL PNEUMONECTOMY FOR BENIGN BRONCHIAL ADENOMA\*

### CASE REPORT

M. DAWSON TYSON, M.D.† AND N. T. MILLIKEN, M.D.†  
HANOVER, NEW HAMPSHIRE

THOUGH bronchial adenoma has become definitely separated from bronchial cancer and other benign bron-

ions as to the origin and pathogenesis of this tumor. Originally confused with cancer or sarcoma (early 1930's), it was

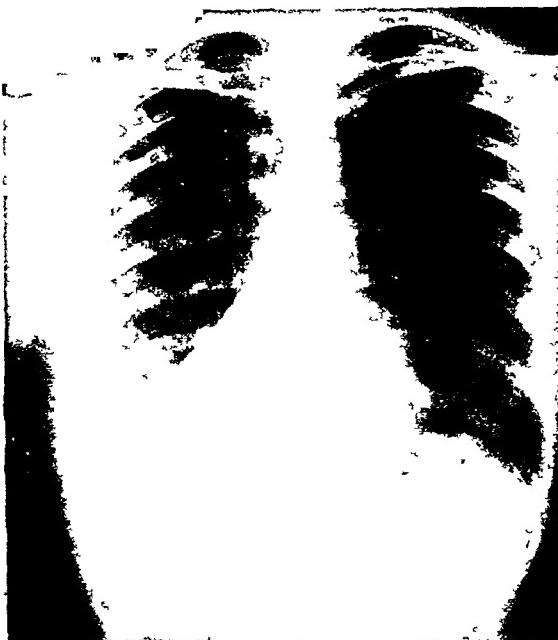


FIG 1 Atelectasis of right middle and lower lobes July, 1939

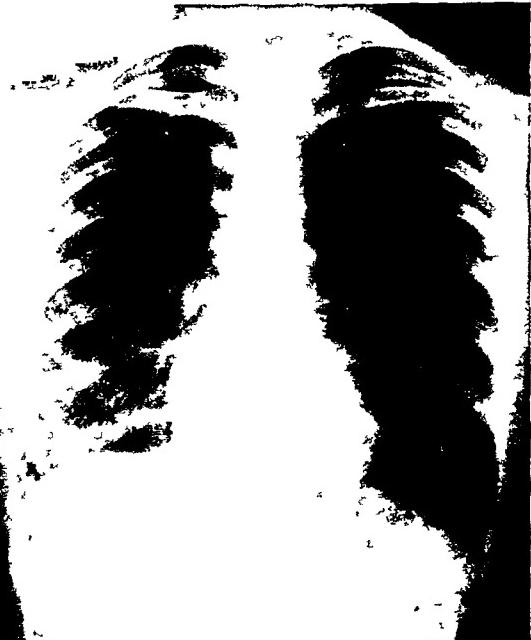


FIG 2 X-ray taken one month after Figure 1. Atelectasis has disappeared but there are increased lung markings in right lower lung field.

chial tumors, some aspects of the life history of this neoplasm are still largely obscure. It is well known that the lesion is slowly progressive, occurs in the majority of cases in women in the third or fourth decade of life, and that in most instances the chief danger lies in the effects of bronchial obstruction produced by the growth. There are, however, varying opin-

later considered entirely benign. Of late, there has been a swing toward the viewpoint that the tumor is usually benign but may become malignant. Thus, in 1938, Womack and Graham<sup>1</sup> stated that in their opinion it is a mixed tumor and may at any time become malignant and metastasize. Basing their decision largely on the pleomorphism of the growth, these authors

\* From the Mary Hitchcock Memorial Hospital, Hanover, New Hampshire.  
† On leave of absence.

expressed the belief that this lesion is the underlying factor in pulmonary sarcoma, oat-cell carcinoma of the lung, and many



FIG. 3. Bronchographic demonstration of obstruction in right lower and middle lobe bronchi

of the bronchial adenocarcinomas. Further corroboration of the viewpoint that malignancy may arise in these tumors was given in an article by Adams, Steiner and Block,<sup>2</sup> in 1942, and again by Anderson,<sup>3</sup> in 1943. These authors found definite, distant, metastatic foci in three cases of so-called bronchial adenoma. Though this is probably a rare occurrence, the possibility of malignant change in any given instance of adenoma would certainly modify the type of therapy proposed in such cases, and the frequently reported treatment of these lesions by endobronchial removal often combined with deep x-ray therapy or direct radium implantation should certainly be questioned. In late years there have been a good many surgeons who have reached the viewpoint that sooner or later pulmonary resection will have to be done in the majority of cases even without the question of malignancy because, even though the tumor is apparently eradicated by numerous bronchoscopic manipulations, the patient continues to carry an infected

and often useless lung distal to the site of the tumor.

Another contraindication to bronchoscopic removal is the fact that the adenoma is often not restricted to the lumen and wall of the bronchus, but penetrates the wall and expands extra-bronchially as well, so that it is beyond the reach of the bronchoscopist. These facts were emphasized by Stephens and Goldman,<sup>4</sup> in 1941. These authors have summarized the literature on adenomas, as has Foster-Carter.<sup>5</sup> The latter found one hundred recorded cases up to the time of his publication (1941).

The condition is uncommon and the results of therapy have not been determined over a long period of time in many individuals so that it seems justifiable to report all cases which occur in order that the knowledge thus accumulated will afford a therapeutic guide and provide a better understanding of the natural history of this lesion.

#### CASE REPORT

The patient is a married woman who was admitted to the Mary Hitchcock Memorial Hospital in January, 1940, at the age of twenty-seven. A history was obtained of a long siege with pneumonia five years before, followed by an interval of good health. In May, 1939, she caught cold and developed a non-productive cough associated with a low grade fever. Several days after the onset, right chest pain appeared and the diagnosis was made by her doctor of pleurisy with effusion. After an illness of fifteen days, the cough entirely disappeared. In July, 1939, at the insistence of the telephone company for which she worked, an x-ray of the chest was taken and a sputum specimen was examined. The sputum was reported negative for tubercle bacilli and the x-ray, reproduced in Figure 1, showed atelectasis of the right lower lobe with possibly some chronic infection, and a similar involvement of the middle lobe. On August 10, 1939, another x-ray (Fig. 2) showed that there was only slight remaining increase in the lung markings at the right base and slight thickening of the interlobar septum. In November, 1939, an x-ray showed recurrence

of the atelectasis in the lower and middle lobes. In December, the patient developed another cold and was away from work for

cells, 9 of which were stab forms. A second strength tuberculin test was negative. Bronchoscopy was carried out by Dr. John A. Murtagh

## MARY HITCHCOCK MEMORIAL HOSPITAL

No. A-5206

Name Della Obey

Date 2-14-40

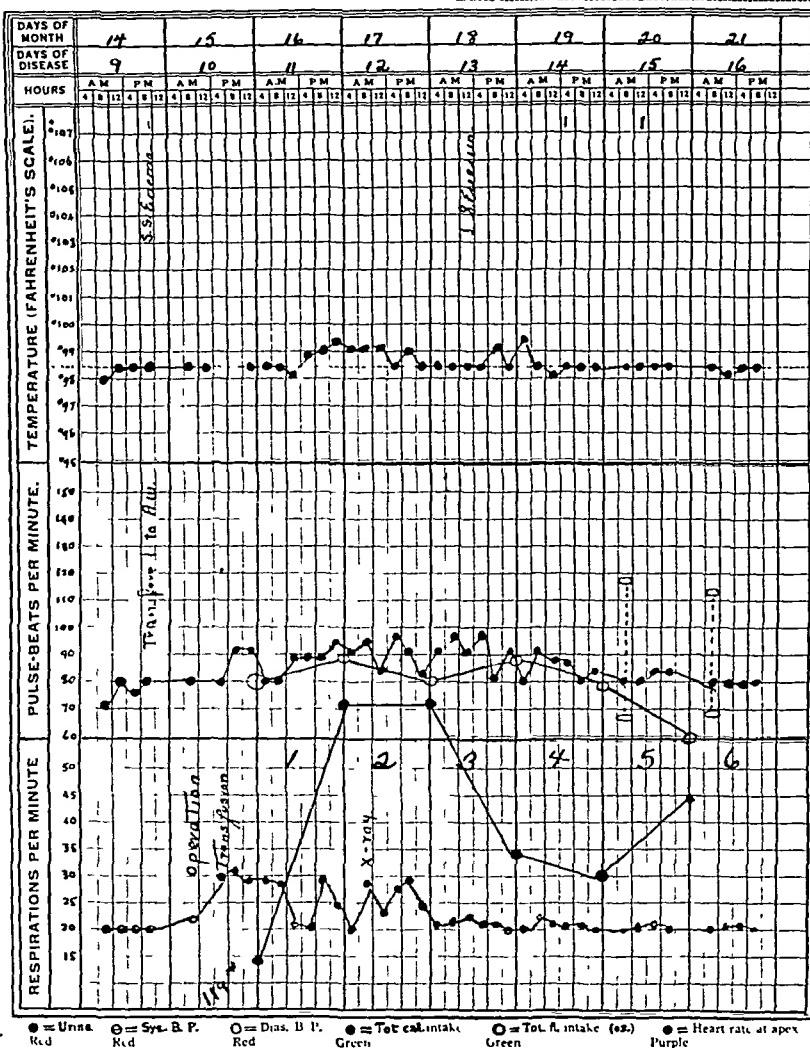


FIG. 4. Graphic chart of vital signs just prior to and following operation.

six days. There was a return of the right pleuritic pain with cough, which became productive for the first time. The sputum was still negative for tubercle bacilli.

She was admitted to the hospital in January, 1940, at which time physical examination was entirely negative except for decreased aeration of the lower and middle lobes on the right. The usual laboratory examinations were negative. The red blood count was 4,790,000 with 14.4 Gm. of hemoglobin, and the white blood count was 5,200 with 61 polymorphonuclear

and a large, rounded tumor with a fairly broad base was found occupying the right stem bronchus and completely occluding the middle and lower lobe bronchi. It was thought that the upper lobe was well aerated. The tumor was firm and very vascular. Bronchoscopic biopsy was obtained and the tissue was diagnosed by Dr. Ralph Miller as benign bronchial adenoma though there was some question as to whether the tumor might not be very active. A suggestion of malignancy was held out by the pathologist, and another specimen requested.

Lipiodol examination at this time confirmed the impression of complete obstruction of the right middle and lower lobes. (Fig. 3.) It was

standpoint of contamination, it was thought safer to transect the bronchus without preliminary bronchoscopic removal of the tumor,

FIG. 5.



FIG. 6



FIG. 5. The tumor is seen completely occluding stem bronchus to middle and lower lobes.  
FIG. 6 Profile view of bronchus showing rounded edge of tumor in lumen and "hump" of tumor protruding through wall of bronchus.

assumed that there was bronchiectasis of the lobes or at least a "drowned lung" condition distal to the tumor.

Thoracotomy was decided upon as the safest method of treatment in this case. From the

since the obstruction was complete and there was no sputum. Preliminary pneumothorax was instituted and a complete collapse of the right lung was obtained for one week prior to operation.

On February 15, 1940, operation was performed. Under intratracheal anesthesia a right anterior incision was made extending

pneumonectomy was carried out by incising the mediastinal pleura and securing the two main branches of the right pulmonary artery.



FIG. 7. Adenoma cut in two; upper lobe bronchus clear, mucopurulent material lying in middle and lower lobe bronchi.

from the angle of Louis downward and laterally in the mammary fold. The breast and pectoralis major were reflected upward and the fourth costal cartilage and anterior portion of the rib were removed. In opening the pleura it was found that the lung was completely atelectatic and there were only a few delicate, avascular adhesions present. In palpating the hilum the tumor mass could be felt protruding through the posterior surface of the main bronchus. It was seen that there was no anatomical separation between the upper and middle lobes. The lower and middle lobes were indurated throughout. A total pneumonectomy was decided upon because it was believed that if the tumor were to be completely removed, the incision in the bronchus would come so close to the upper lobe bronchus that closure of this structure would be inadequate or impossible. Also, if total pneumonectomy were not done, transection of infected lung tissue would have to be carried out, which would add to the risks involved. In addition, there was still no complete assurance of the benign character of the growth. Therefore, total



FIG. 8. Coronal section of lung; middle and lower lobes atelectatic; saccular dilatations of bronchi which are filled with mucopurulent exudate; no separation between upper and middle lobes

The two pulmonary veins were similarly treated, ligation of all vessels being carried out within the mediastinum. The pulmonary ligament was then severed between clamps and the bronchus was dissected free. A ligature of braided silk was passed around the bronchus just distal to the tracheal bifurcation and tied snugly but not with crushing force. The bronchus was then divided just distal to the ligature and the end was sutured over with mattress sutures of No. 00 chromic catgut. The mediastinal pleura was then sutured over the end of the bronchus and the incision in the mediastinal pleura was closed with interrupted silk sutures. The hemithorax was irrigated with saline and the incision closed with silk. A transfusion was given though there had been but scant blood loss, and the patient was placed in an oxygen tent.

The chart of her postoperative course is depicted in Figure 4 and shows a very benign reaction to operation. The patient was not really sick at any time. Some fluid accumulated

in the right pleural cavity. This was aspirated one week after operation, cultured, and found to be sterile. On February 17th (two days

manner, the extrinsic portion being about a fourth as large as that portion within the lumen. The middle and lower lobes were com-

FIG. 9.



FIG. 10.



FIG. 9. The adenoma extends extrabronchially between two cartilage plates.  
The larger portion is endobronchial.

FIG. 10. Microscopic appearance of a typical area in the adenoma. The pleomorphic characteristics are shown.

postoperatively), her red blood count was 4,410,000 with 16.4 Gm. of hemoglobin. The patient was allowed up on the fourteenth postoperative day and was sent home on the twenty-first day. She was allowed to go back to her work as a telephone operator in a month and has been working practically uninterruptedly since.

Examination of the surgical specimen showed that the tumor was a benign adenoma. The adenoma had protruded through the posterior surface of the bronchus in a collar-button

completely obstructed and the bronchi of these lobes were filled with mucopurulent material. There were saccular dilatations of the smaller bronchi and these sacculations also were filled with mucopurulent material. The parenchymatous tissue of these lobes was completely atelectatic. Pictures showing the anatomical situation are reproduced in Figures 5, 6, 7, 8 and 9.

Microscopically the tumor shows the usual pleomorphic structure that has been so often described. (Fig. 10.) In some areas there

is fairly definite acinar formation, while in others the epithelial elements are arranged in columns and occasionally in sheets. The

structures to the right with great increase in size of the left lung. The trachea is sharply angulated to the right. The right thoracic cage is

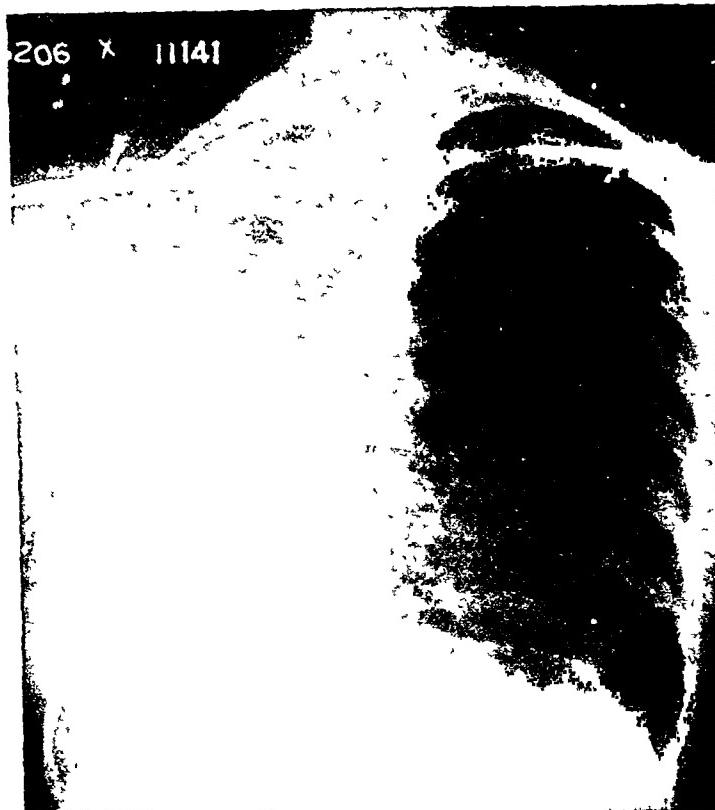


FIG. 11. Intrathoracic alterations sixteen months after pneumonectomy. There is angulation of the trachea with extreme shift of this structure to the right. The right diaphragm is elevated and the left lung has extended across the mid-line.

supporting stroma is very vascular. There is no invasion of the basement membrane nor any invasion of adjacent tissue and the tumor is well encapsulated throughout. Examination of lymph nodes in the region of the bifurcation of the bronchi failed to demonstrate metastatic foci. A lymph node which had been removed from the mediastinum also failed to demonstrate any metastatic involvement by tumor tissue.

The patient has been followed faithfully in the clinic. Her vital capacity taken in the out-patient department in April, 1940, was 60 per cent of normal, and in September (seven months after operation) this had risen to 2,700 cc., which was considered 70 per cent of normal. An x-ray, taken on November 1, 1941, sixteen months after operation, is shown in Figure 11. This picture shows advanced changes in the thorax due to shifting of all struc-

contracted and is occupied by the mediastinal structures and the left lung. The right diaphragm is elevated. If the patient walks briskly up a fairly steep grade she becomes a little breathless, and at such times she notices that her breathing is noisy, probably due to the angulation of the trachea. In February, 1942, the patient underwent an operation on her foot for hallux valgus. This operation was done under spinal anesthesia and was well tolerated. On January 11, 1943, three years postoperatively, the patient's vital capacity had risen to over 90 per cent and she stated that she could accomplish more than she could in the previous year. On the same visit the red blood count was 5,440,000 and the hemoglobin was 15.4 Gm. In April, 1944, the patient was delivered of a normal offspring at term. She had a completely normal convalescence from this event.

## COMMENTS

Total pneumonectomy was performed in this case for several reasons. In the first place, there was no absolute assurance that the growth was benign and as soon as the chest was opened palpation revealed that the growth had extended through the bronchial wall posteriorly, which was considered a further indication for radical surgery. Also, the lesion was situated so near the primary division of the right main bronchus that it was doubted that closure of the upper lobe bronchus could be effected after sufficiently high section of the stem bronchus of the middle and lower lobes. Finally, the fact that there was complete anatomical fusion of the upper and middle lobes meant added technical difficulties in performing a partial operation, with the increased danger of empyema following transection of infected lung tissue.

The advisability of performing a thoracoplasty after pneumonectomy is still open to question. Certainly this individual's lung has been overdistended to practically twice its normal volume and in view of the work of investigators in this field such distention may not be an entirely desirable result because of the likelihood of the development of serious pulmonary emphysema due to loss of elastic tissue. Unfortunately, thoracoplasty cannot be carried out successfully after the appear-

ance of symptoms of emphysema because it is a one-way reaction, and reducing the size of the thoracic cage at such a time would not be of benefit.

It has been over four years since the patient was operated upon and she is now thirty-one years of age. Her only subjective difficulty is that if she walks rapidly up a steep hill there is some shortness of breath and wheezing. There is no evidence of recurrence or metastasis. She is able to carry out her housework and her duties as a telephone operator without respiratory embarrassment. She had a normal delivery and puerperium in April, 1944. The future alone can tell whether the lung tissue in this case will eventually break down due to rupture of elastic tissue from overstrain. Against this possibility it is interesting to note that the patient's vital capacity and ability to carry out her ordinary activities have progressively improved in the four years following operation.

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# REGIONAL JEJUNITIS\*

## REPORT OF AN UNUSUAL CASE†

VINCENT L. REES, M.D.

Assistant Professor of Surgery, University of Utah Medical School

SALT LAKE CITY, UTAH

**N**ON-SPECIFIC inflammatory conditions of the intestinal tract are not rare, but it is unusual to see these conditions in the upper gastrointestinal tract without a similar pathological condition in the terminal ileum. Likewise these inflammatory conditions seldom cause complete intestinal obstruction. The following report illustrates a case of segmental jejunitis causing complete intestinal obstruction:

### CASE REPORT

K. W. (No. 521545), a thirty-two year old married negress, was admitted to the University Hospital complaining of abdominal distention and pain. For the past two or three years she had been troubled with "indigestion." This consisted of crampy mid-epigastric pain that usually appeared three to four hours after meals. Occasionally, the pain would be present during or soon after eating. The pain did not radiate but was aggravated by ingesting fatty foods. It was relieved by milk, soda, and stomach powders.

About five months prior to admission, and following a "fish supper," abdominal distention appeared. There was considerable associated borborygmus, and about twelve hours later she vomited the contents of the meal. Since then she had had several similar episodes of distention. For two weeks preceding her admission her abdomen was persistently distended; there were gaseous eructations, borborygmi, and a burning sensation in her pharynx. She had vomited only occasionally and then in small amounts. Bowel movements had been regular and without abnormalities. Ankle edema had been present for two weeks prior to admission.

The past history revealed an amenorrhea of three months' duration, and a spontaneous abortion nine months before admission. She had been married for fifteen years and had two children that were living and well. There was no history of tuberculosis or lues.

Physical examination revealed a chronically ill, emaciated young negress. There was obvious generalized edema which included the eyelids, cheeks and ankles. Her temperature was 99°F. orally, pulse 100 per minute, and respirations were 20 per minute. The significant physical findings were limited to the abdomen. It was greatly distended and there were loud borborygmic sounds. Numerous vigorous peristaltic waves were visible and on palpation several distended loops of bowel could be felt. There was a fluid wave and shifting dullness. By rocking the patient a succussion splash could be heard. Rectal and pelvic examinations were non-contributory. The heart and lungs were essentially normal and there was no lymphadenopathy.

Urinalysis was negative. The leukocyte count was 2,800 with 82 per cent polymorphonuclears and 14 per cent lymphocytes. The erythrocyte count was 3.97 million with a hemoglobin of 65 per cent Sahli. The carbon dioxide combining power of the blood was 68 volumes per cent; the non-protein nitrogen 31.4 mg. per cent; the serum chlorides 546 mg. per cent, and the serum protein 5.8 Gm. per cent.

Upon admission to the ward a scout film (flat plate) was taken of the abdomen. It revealed extreme distention of loops of small bowel set in an oblique pattern. (Fig. 1.) The transverse colon also contained gas, but was not particularly distended. On the basis of the history and x-ray findings a diagnosis of chronic small bowel obstruction was made. Due to the patient's poor general condition, and the

\* From the Department of Surgery, University of Utah Medical School, Salt Lake City, Utah, and the Department of Surgery, University of Michigan.

† The case presented is of a patient treated in the University Hospital, University of Michigan, Ann Arbor, Michigan.

chronic character of her illness, it was decided to treat her conservatively, hoping that her general condition could be improved before

was a moderate amount of fibrin about the edematous and dilated bowel. The obstruction appeared to be due to inflammatory strictures



FIG. 1. Scout film showing extreme distention of small intestines. Some gas is also present in the colon and the stomach.

surgery. A Miller-Abbott tube advanced as far as the proximal jejunum where it stopped. Despite the aspiration of large amounts of fluids and gas the distention was only partially relieved. All attempts to get the tube to progress further failed, even though there were distended loops of small bowel in the region of the tip of the tube.

Under conservative therapy the patient showed little improvement and forty-eight hours after admission she was operated upon. The abdomen was opened through a right transverse incision which passed just below the umbilicus. The tissue of the abdominal wall was very edematous. Upon opening the peritoneal cavity a large amount of ascitic fluid escaped and greatly distended loops of small bowel presented themselves. Upon investigation it was found that the distended loops were jejunum. The distended jejunum was easily delivered into the incision. There

of the bowel wall. There were four such constrictions involving three segments of jejunum. (Fig. 2.) The uppermost constriction was only 20 cm. from the ligament of Treitz. The other three constrictions were scattered along the jejunum at varying distances for about four feet. Careful examination failed to reveal other lesions in the gastrointestinal tract. Approximately five feet of jejunum, including the four constrictions, were resected and an end-to-side anastomosis made between the distal and proximal segments of jejunum. The end of the distended (proximal) loop was anastomosed to the side of the collapsed (distal) loop. The incision was closed without drainage. During and immediately following the operation the patient received 500 cc. of blood and 500 cc. of plasma. The Miller-Abbott tube was replaced by a Levin tube, and constant Wangensteen suction applied. She was given oxygen per B.L.B. mask.

On the day following operation she was given another 500 cc. of plasma, and because of her complaints the mask was replaced by nasal

with vascular pyogenic granulation tissue. The base of the ulcers involved all the coats with scar tissue. There were marked sclerotic



FIG. 2. Specimen as removed at operation. Note the several areas of constriction with dilated jejunum between. There is also extensive hyperplasia of the lymph nodes in the mesentery.

oxygen. Her leukopenia persisted at about 3,000, so on the second postoperative day she was given pentnucleotide intramuscularly. By this time she was feeling much better. The nasal oxygen was discontinued on the morning of the third postoperative day and she was started on a liquid diet. By that evening she was slightly distended, so stomach suction was renewed and continued overnight. She was given another 1,000 cc. of plasma, following which she improved rapidly. Her leukopenia persisted despite pentnucleotide. Intramuscular liver was started in the hope that it might help correct her leukopenia and better her general condition. She developed a urinary tract infection which was treated by indwelling catheter with intermittent irrigation of boric acid solution. Sulfonamides were not given because of her leukopenia. She improved steadily, and by the eighteenth postoperative day her leukocyte count was 12,500, she was eating regularly, and was ready for discharge. She left the hospital three weeks after the operation. She returned six weeks later presenting a picture of health, having gained forty pounds in weight. At the present time, one year after operation, she has remained symptom free and has continued to gain weight.

The pathologists reported that the resected jejunum contained several chronic ulcers

and obliterative changes in the arteries at the ulcer bases. Their diagnosis was chronic ulcerative enteritis closely related to, or the same as segmental ileocolitis.

#### COMMENTS

As described by Crohn,<sup>1</sup> non-specific inflammations of the gastrointestinal tract occur most frequently in the region of the terminal ileum. Ginzburg and Garlock<sup>2</sup> have emphasized the fact that this disease distributes itself either regionally or diffusely throughout the gastrointestinal tract. When the diffuse type is encountered, the major pathological changes are usually located near the distal ileum. It is unusual to see the proximal jejunum involved without evidence of a similar process more distally. Pemberton and Brown<sup>3</sup> reporting on thirty-nine cases seen over a fifteen-year period list but three cases in which the jejunum alone was involved. Ginzburg and Garlock<sup>2</sup> report seeing twenty-two cases of jeuno-ileitis over a ten-year period, but they make no mention of any case in which the jejunum alone was involved. The third portion of the duodenum was involved in one of the

cases reported by Holloway,<sup>4</sup> but as so often happens, the terminal ileum was involved also.

Though this lesion is obstructive in nature it seldom causes as complete an intestinal obstruction as is illustrated by this case. Even in the more severe cases a narrow channel can usually be demonstrated by x-ray (string sign). The generalized nutritional edema present in this case undoubtedly contributed to the completeness of the obstruction. On examining the gross pathological specimen (Fig. 2) there were at least three areas of constriction, leaving isolated closed segments of small bowel that were greatly distended with fluid and gas. These isolated distended loops did not collapse until the constricting areas were incised. The segmental distribution of the ulcerated constricting areas with uninvolved intestine intervening is characteristic of the segmental type of this disease, and illustrates the so-called "skip areas."

Usually the jejunal variety of this disease is not amenable to surgery as the process extends over such a long segment that resection or side-tracking operations shorten the gastrointestinal tract too much. Due to the completeness of the obstruction in this case it was imperative that something be done. In view of the two isolated obstructed loops of small bowel, resection seemed to be the only rational form of therapy. Where the inflammatory process is limited to the terminal ileum, exclusion procedures are often done, but ultimate

resection is usually indicated. In operating upon patients with this condition one must remember to divide the bowel well above the involved portion in order to avoid recurrences. Where a resection is performed, the mesentery need not be resected deeply, as the disease does not spread via the lymphatics as once thought. The fact that a year has passed since operation and there are no signs of recurrence makes the prognosis in this case quite hopeful. When recurrences appear, they usually manifest themselves within a year and practically always appear before two years.

#### SUMMARY

An unusual case of non-specific regional jejunitis is presented in which the proximal jejunum was completely obstructed at three isolated places. About five feet of jejunum was resected and an end-to-side anastomosis performed. The patient's recovery was uneventful, and she is well and symptom free one year later.

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# CONGENITAL DIAPHRAGMATIC HERNIA\*

## VISCERAL STRANGULATION COMPLICATING DELIVERY

J. W. THOMPSON, M.D.

AND

Diplomate of the American Board of Surgery

LEO J. LE BLANC, M.D.

Resident in Surgery, De Paul Hospital

ST. LOUIS, MISSOURI

**W**E wish to report a very unusual case of congenital diaphragmatic hernia complicating the puerperium. To the best of our knowledge, after careful survey of all similar cases which have been reported in the literature, our patient is the first one in which immediately postpartum surgical intervention has been attempted or successfully accomplished. We believe this case to be unique, because the diagnosis was made some few hours following labor, the hernia repaired, and the patient discharged in excellent condition on the thirteenth post-operative day, having made an uneventful recovery.

### CASE REPORT

Mrs. L. P. entered the Obstetrical Service of the De Paul Hospital at 3:00 A.M. on May 19, 1943, in hard labor. The patient was a thirty-one year old white woman, gravida II. Her first pregnancy, labor, and puerperium were without incident. One hour and thirty minutes after admission, the patient spontaneously delivered a six pound two ounce normal female child. She was returned to her room in apparently good condition. Approximately five hours later, she began complaining of severe epigastric pain and was very restless. She became nauseated and vomited several times. Her respirations were labored and accelerated to 40 per minute. Her pulse at this time was 140. The patient became mildly cyanotic and appeared alarmingly ill. Dilaudid, gr.  $\frac{1}{32}$ , was given for pain. Continuous gastric suction-siphonage was instituted. Oxygen per nasal tube was begun.

Physical examination of the chest revealed a splinted left thorax. The lower two-thirds of the left chest was dull to percussion, and no breath sounds were audible on this side. The

cardiac sounds were best heard well within the midclavicular line. Cardiac dullness was questionably percussible to the right of the sternum. The right chest was resonant to percussion and the breath sounds were normal.

Examination of the abdomen revealed the usual postpartum contour, moderate distention, and generalized tenderness. A mass, which was thought to be an enlarged spleen, could be palpated in the left upper quadrant.

Roentgenograms of the chest and abdomen were taken in the patient's room. There was a marked increased density throughout the entire left lung field. The heart and mediastinal structures were shifted to the right. There was a distinct irregularity of the left diaphragm. The stomach, well outlined by entrapped air, was displaced into the left thorax. The tip of the indwelling nasal tube was disclosed to be in the stomach, which had migrated into the chest cavity. (Fig. 1.)

The patient's condition was becoming progressively worse; her pulse faster and weaker; her pain persisted; she was perspiring profusely; and her temperature was gradually rising. Strangulation of a viscus was feared and conservative treatment appeared no longer effective.

The preoperative diagnosis was left-sided diaphragmatic hernia with progressive strangulation of the hernial contents. (Fig. 2.) The required type of treatment was obviously surgical. Immediate exploration was advised.

Intratracheal cyclopropane anesthesia was used. A liter of normal saline solution plus 500 cc. of whole blood were given immediately by vein to combat shock.

A long left rectus incision was made from the xiphoid process to the left of the umbilicus. On opening the peritoneal cavity, considerable murky, free fluid was discovered and aspirated from both the abdominal and left thoracic cavities. There was a large congenital diaphragmatic hernia, through which all of the

\* From the Department of Surgery, De Paul Hospital, St. Louis, Missouri.

hollow viscera of the abdomen had migrated into the left thorax. The mesenteries of the stomach and intestines were elongated and

postpartum uterus was well contracted in the pelvis.

The margins of the hernial opening were



FIG. 1. Roentgenogram made with portable apparatus. This film was taken to include both thoracic and abdominal areas. Note the nasal tube extending into the left thoracic cavity. The arrows delineate a shadow of the walls of a hollow viscus, probably the stomach. There is no "gas pattern" whatsoever in the abdominal field. The upper portion of the left thoracic area was almost entirely opaque.

there had been a complete, counterclockwise rotation, causing torsion of the pancreas, which was acutely inflamed and covered by a fibrinous exudate with numerous characteristic areas of superficial fat necrosis. The only organs remaining in the abdomen were: the spleen, which was enlarged to about twice its normal size; the liver, which was also enlarged and extended three or four finger-breadths below the costal margin; and the descending colon.

The viscera were easily replaced within the abdominal cavity. The gallbladder was blue and thin-walled. The appendix appeared to be normal. It was not disturbed. The recently

freshened with scissors and were approximated and overlapped about 1 cm., using interrupted sutures of No. 1 chromic catgut. A second row of interrupted heavy black silk sutures was inserted to reinforce the line of approximation.

The operative site and the incision were sprinkled with approximately 10 Gm. of sulfanilamide powder. The abdominal wall was then closed in anatomical layers without drainage.

The patient experienced a rather normal postoperative course. Constant gastric suction-siphonage was maintained for the first three postoperative days. Her fluid balance was maintained with parenteral glucose-saline solutions. Small, whole blood transfusions were

given to support her general condition. On the third day, her breasts became painfully engorged, for which stilbestrol, 5 mg. three

This patient had evidently compensated for unusual intra-abdominal and intrathoracic pressure changes throughout her lifetime, and

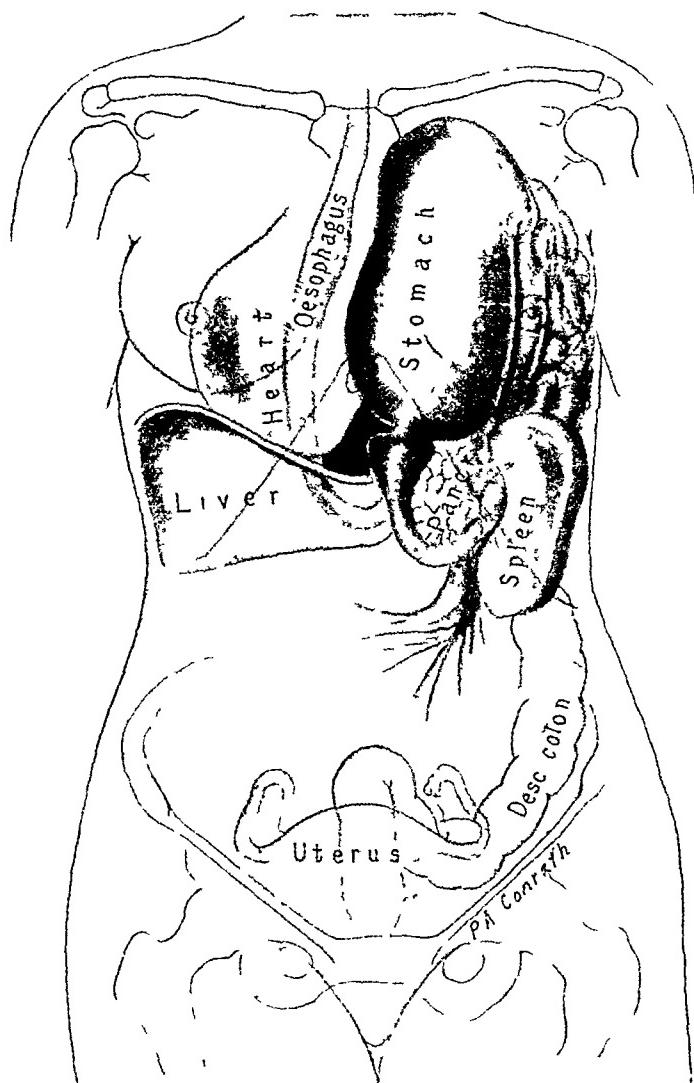


FIG. 2 A semi diagrammatic representation of conditions discovered at operation. The liver, spleen, descending colon, and uterus were the only organs remaining in the abdominopelvic cavities

times a day, was given for three days with complete relief.

On the eleventh postoperative day, roentgenograms of her chest were made. (Fig. 3.) Examination of these plates showed an almost complete collapse of the left lung with an extensive pneumothorax of the same side. There was a marked depression of the left diaphragm. No fluid level could be seen.

The patient was discharged on her thirteenth postoperative day in excellent condition. Her infant made normal progress.

it seemed quite evident that her abdominal viscera had been making numerous and repeated excursions between both the abdominal and thoracic cavities without causing any symptoms of which the patient became aware. There was some question as to whether the left lung had ever been expanded completely to its normal capacity. For this reason, repeated examinations of the patient's chest were made. The breath sounds and percussion notes gradually became normal, and a chest plate made on August 3, 1943 (Fig. 4), demon-

stated that the left lung had completely expanded except at the costophrenic angle.

Roentgenologic examination of the thorax and gastrointestinal tract on this day revealed a low-lying, atonic stomach situated below the left leaf of the diaphragm, which moved normally, although its motion might possibly be considered slightly restricted.

The colon was markedly redundant and atonic. That the mesenteries were still abnormally elongated could be demonstrated by the ease with which these barium-filled viscera could be manipulated to distant corners of the abdominal cavity. (Fig. 5.)

#### COMMENT

Diaphragmatic hernia associated with pregnancy has been observed previously. It is possible for a patient harboring such an anomaly to undergo repeated labors without incident. In this patient, the unusual increase in intra-abdominal pressure caused by the contracting pregnant uterus prior to delivery, combined with straining of the abdominal muscles, unquestionably forced the abdominal viscera into the thoracic cavity with considerable violence. These forces, in addition to those of more or less excessive peristaltic contractures, could account for the counter-clockwise torsion and rotation of the mesenteries. Such violent phenomena may not occur in every instance. The fact that this patient underwent her first pregnancy and delivery without incident would be confirmative. Therefore, it is probable that this condition remains undiscovered in many women simply because its presence is not suspected. A patient reported by Diddle and Tidrick<sup>2</sup> had undergone three uneventful deliveries yet succumbed shortly after the fourth. Autopsy was done on this patient and it is stated that the pancreas weighed 100 Gm. and contained large areas of hemorrhage, particularly toward the tail, with pancreatic necrosis. Undoubtedly, the cause of death in this patient was interference with the visceral blood supply produced by the strangulation at "the neck" of

the hernial sac, which, in such instances, is formed by the opening in the diaphragm.

It would certainly not be considered good judgment to undertake as an elective procedure a formidable operation involving the organs of both the thorax and the abdomen in a woman who had just been delivered. However, the possibility of visceral strangulation was definitely considered in our patient, and emergency surgery was advised and undertaken as the only possible measure which would save the patient's life. It is our opinion that the use of intratracheal cyclopropane anesthesia, plus the usual supportive measures, contributed in no small way to the good result obtained. The most important factor, nevertheless, was the decision to operate immediately despite all hazards. Quite obviously, it would have been an advantage to have diagnosed the diaphragmatic hernia before pregnancy, so that its repair could have been undertaken under more ideal circumstances.

Since many women must harbor such congenital anomalies, the importance of careful clinical and roentgenologic studies of the thoracic organs of pregnant women would seem of paramount importance. Quite possibly, in early pregnancy, a repair of diaphragmatic hernia, either through the abdominal approach or by the transthoracic method, could be accomplished without unusual danger of miscarriage. In the later stages of pregnancy, the risk to both the life of the unborn infant and that of the mother would seem prohibitive. The grave danger of strangulation of abdominal viscera, followed by necrosis and subsequent death of the patient, is all too apparent.

Selection of the abdominal or transthoracic approach in the surgical treatment of strangulated diaphragmatic hernia in complicating pregnancy or delivery cannot be discussed on the basis of repeated experience. It would seem, however, that the abdominal approach in such cases is more preferable. There is probably less added shock to an extremely sick

patient. There might also be circulatory damage to the abdominal viscera requiring manipulations or possibly resection, which

anomaly long before the child-bearing age. The choice of either surgical approach as an uncomplicated elective procedure



FIG 3. Roentgenogram of chest made on eleventh postoperative day, showing pneumothorax on left side. Arrows denote shadow of collapsed left lung and the restored contour of the left diaphragm, which occupies a position somewhat lower than the corresponding right diaphragm. The cardiac outline has a rather unusual gourd-like contour.

would certainly be somewhat more difficult if attempted transthoracically. Such contingencies, however, could admittedly take place only in those patients in whom a proper diagnosis was made at a relatively late period. It is also logical to assume that adhesions between the viscera of the entrapped abdominal contents and those of the thorax would produce symptoms which should lead to a diagnosis and surgical correction of such a congenital

is a matter of individual surgical experience and practice. The abdominal route was selected in our patient, because it seemed to be the quicker and easier of the two. The fortunately good result in this instance, at least, would vindicate our judgment.

The scarcity of reports in medical writing of this rather unusual complication of pregnancy and the puerperium does not exclude the possibility that it might occur

more commonly than suspected. It is quite possible that death in the immediate hours following delivery might be caused

sisted in for longer than a very few hours if the patient's response and improvement is not immediate.

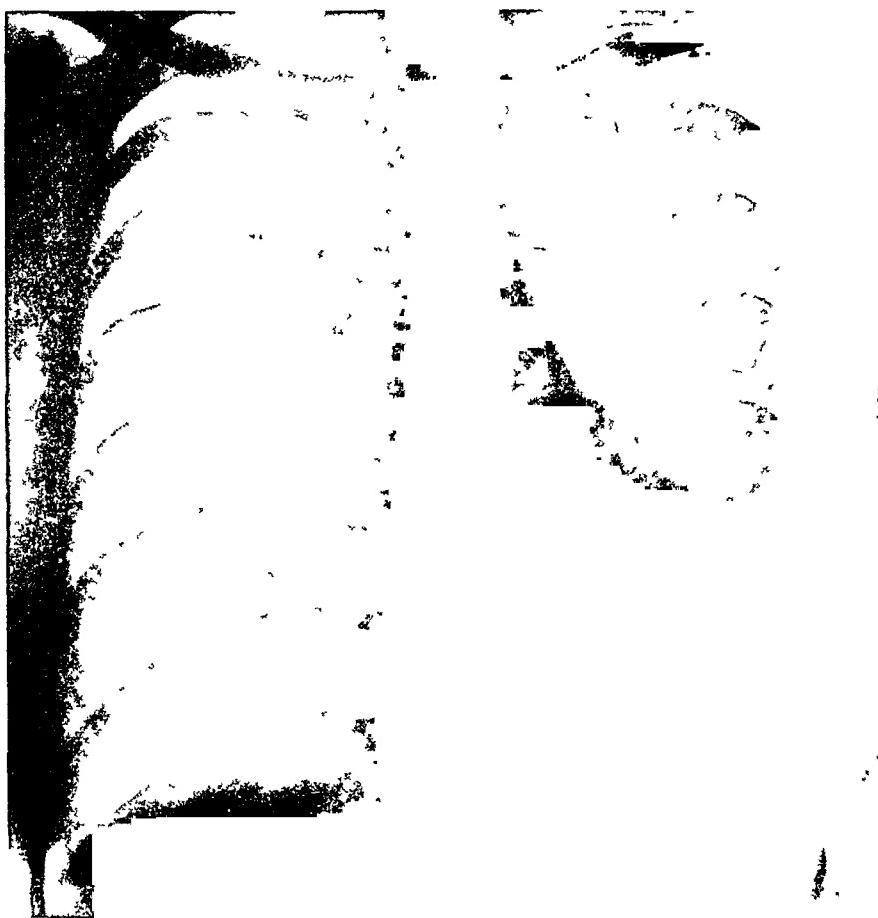


FIG. 4 Roentgenogram of the chest on August 3, 1943, demonstrating that the left lung has re-expanded. The cardiac outline occupies a relatively more normal position. There is still a compensatory over-expansion of the right lung, causing a shift of the mediastinum to the left. Breath sounds and other physical findings were normal.

by the unsuspected presence of this complication.

The excellent results obtained in surgical repair in all types of diaphragmatic hernia, as reported by Harrington,<sup>4</sup> Truesdale,<sup>6</sup> and many others, would certainly justify recommending such procedures during the child-bearing period of life.

A case of diaphragmatic hernia complicating pregnancy reported by De Lee and Gilson,<sup>1</sup> responded to conservative treatment by gastric suction-siphonage, nasal oxygen, and sedation. It is our opinion, however, that if such measures are undertaken, they should not be per-

Four fatal cases of diaphragmatic hernia diagnosed during pregnancy have been found in the literature. These are mentioned in the report of Diddle and Tidrick.<sup>2</sup> One of these patients was operated upon for appendicitis during the sixth month of pregnancy, but the appendix could not be located and the hernia was not found. The patient expired a few hours after operation, and at autopsy part of the large and small bowel were found incarcerated through the diaphragmatic defect. The other three patients had acute symptoms suggesting ileus at the fourth, eighth, and tenth lunar months, respec-

tively. Two of the three hernias were not diagnosed before necropsy, while the fourth was visualized on roentgenographic films.

hernias in women of child-bearing age, and the urgency of advising surgical repair.



FIG. 5. Roentgenogram of barium enema made on August 3, 1943, demonstrating a markedly redundant and atonic colon. The elongation of the mesenteries was evident, because of the ease with which the viscera could be moved throughout the abdominal cavity visualized by fluoroscope.

Two of these women (eight and ten months' pregnant) became ill with the onset of labor; one died the day after delivery, while the other lived only a few minutes after the third stage was completed. The last patient died in the fourth month as the result of acute strangulation of the hernia.

This brief summarization of four fatal cases serves to emphasize the importance of suspecting the presence of diaphragmatic

#### SUMMARY AND CONCLUSIONS

Diaphragmatic hernia in pregnancy is not a common complication. The literature contains only a small number of reported cases. Four fatal cases diagnosed during pregnancy have been reported.

Two cases of diaphragmatic hernia complicating the immediate puerperium, treated by conservative measures without fatality, are all that the literature supplies.

The case report herewith submitted is, to the best of our knowledge, the first one in which the patient has been operated upon with a successful result. The surprisingly uneventful recovery of the patient would seem to recommend surgical treatment of this complication immediately upon diagnosing strangulation, since a time-honored principle in the treatment of all types of strangulated hernias is immediate emergency surgical intervention.

This complication will arise again. Its diagnosis is not difficult. Conservative treatment should, of course, be attempted. Constant observation, tempered with the thought of the possibility of strangulation of the hernial contents, should be the ever present consideration of the attending obstetrician.

Surgical repair of large, congenital or acquired diaphragmatic hernias during early pregnancy would seem justifiable because of the very grave danger of

strangulation during the later months of gestation or as a complication of delivery or the puerperium.

We are greatly indebted to Dr. H. A. Klein and to Dr. D. B. Flavan for the opportunity of seeing this patient in consultation. It was they who made an early and correct diagnosis and urged us to undertake the surgical procedure, which was fortunately successful.

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# NEUROFIBROMA OF THE CAROTID BODY

EDWARD GOODSTT, M.D.  
Pathologist, Huron Road Hospital

AND  
GEORGE SUDIMACK, M.D.\*  
Resident in Surgery, Huron Road Hospital

EAST CLEVELAND, OHIO

NUMEROUS cases of tumor of the carotid body have appeared in the literature and several recent com-

case. Although these tumors are frequently multiple, the case presented shows no evidence of other similar tumors.



FIG. 1. Neurofibroma of carotid body.

prehensive reviews of this subject have been made. The majority of these tumors are characteristic arising in the epithelial type of cell. A few tumors of nerve cell origin have been recorded and these are definitely in the minority. The purpose of this paper is to present another case of carotid body tumor showing a neurofibromatous character with no evidence of epithelial tissue in the tumor. Clinically, the tumor showed symptoms and signs similar to those in the usual carotid body tumor. The tumor proved to be a neurofibroma arising apparently from the glossopharyngeal nerve. Neurofibromas of the cranial nerve other than the acoustic nerve are uncommon and the symptomatology of such tumors depends upon the location and nerve involved. The pathological picture, however, is characteristic of neurofibroma in the following

## CASE REPORT

Mrs. R. M. age thirty-eight, was admitted to Huron Road Hospital September 12, 1943. She complained of a mass in the right side of the neck of approximately six years' duration. The mass had been enlarging for the past two years and had become conspicuous. The patient wished to have the mass removed mainly for cosmetic reasons. The family history of the patient was essentially negative except for the fact that her father died of carcinoma of the liver. The past history of the patient showed nothing of importance. Examination showed a well nourished, alert, young female with no apparent abnormalities except a swelling on the right side of the neck. Here, there was a large, round, firm mass extending from a point just below the lobe of the ear, midway into the neck along the sternocleidomastoid muscle. The mass could be moved horizontally; vertical motion, however, was limited. Examination of the heart showed it to be of average size, with normal

\* Dr. Sudimack is now on active duty with the United States Naval Reserve.

force, rate and rhythm. The pulse was of good volume. The blood pressure was 130 systolic, 85 diastolic.

The patient was taken to surgery on September 14th for removal of the tumor. The incision was made in the right side of the neck just below and parallel to the angle of the jaw over the tumor mass through the skin, subcutaneous tissue and platysma. The incision was carried down until the capsule of the tumor was found and examination of the mass showed it to be within the carotid sheath, covering the external and internal carotid arteries. The jugular vein and vagus nerve coursed over the top of the tumor. By sharp and blunt dissection the tumor was removed without injury to the remaining contents. After removal of the tumor the sheath was closed. The muscle fibers were brought together with plain catgut, the platysma was brought together with plain catgut, and the skin was closed with clips. A sterile dressing was applied and the patient was returned to bed in good condition.

The immediate postoperative course appeared satisfactory with the exception of a slight occasional irregularity of the pulse. The blood pressure fluctuated between 150 and 100 systolic and after twenty-four hours leveled off to 130 systolic and 80 diastolic. The morning following the operation, the patient complained of numbness of the right side of head, tongue, lips and cheek. This sensation and numbness disappeared within the next twenty-four hours, except for the numbness of the right side of the tongue. The patient was discharged on September 21, 1943, in a definitely improved state.

Five weeks postoperatively, the patient presented no clinical abnormalities and the feeling of numbness of the tongue was gradually disappearing.

The pathological examination revealed the following: Specimen consists of a tumor mass measuring 7 cm. in length 4 cm. in diameter, partially covered by a thick, opaque, fibrous capsule. On section, the tumor shows a nodular structure with one large nodule present measuring 2½ cm. in diameter, showing the tissue fleshy, yellowish gray with small hemorrhagic areas present. In other areas the tumor is hard, coarse, gray with a fibrous architecture. There are present several small lymph nodes, the largest 7 mm. in diameter. On section, the tissue is fleshy, yellowish gray.

**Microscopic Examination:** Section one shows portion of a tumor with a thick covering of fibrous tissue with scarring and infiltration by round cells here. In the deeper portion, the tumor shows large masses of spindle cells, with definite palisading of the nuclei and there is considerable loose fibrillar stroma present. In other areas, there are large cells suggesting ganglion cells also lying in a fibrillar stroma. A few nests of large clear staining cells are also seen. Section two shows a similar picture with considerable old and recent hemorrhage, considerable scarring and infiltration by round cells and some pus cells. Final diagnosis: neurofibroma.

The carotid body is classified as one of the chromaffin glands and has as its main constituent large polyhedral cells resembling epithelium. The cells are arranged in alveolar formation with no ducts or gland lumina present. They have a rich capillary and nerve supply. Anatomically, they are closely related to the carotid sinus and receive their nerve supply from this structure. The actual function of this gland is not known and its tumors have no apparent endocrine significance. Tumor formation is the only important disorder of this body and numerous such tumors have been described. The majority of these tumors arise from the large polyhedral epithelium-like cells which are arranged in alveolar or syncytial masses. In some cases the connective tissue or vascular stroma may predominate. This type of tumor suggests origin in paraganglionic tissue. A few cases in the literature show predominance of neurofibromatous elements with elongated cells arranged in bundle-like units and showing palisading of the nuclei. This type of tumor arising in the carotid body is very unusual. The case reported is of this type with predominance of neurofibromatous tumor tissue, although a few ganglionic cells were seen.

#### SUMMARY

A case of an unusual neurofibromatous type of carotid body tumor is presented.

The clinical features were similar to those of the ordinary epithelium-like cell tumor of the carotid body.

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HYPERTHYROIDISM results from an excessive absorption of the thyroid secretion (*thyroxin*) and is characterized by the stimulation of nearly every bodily function. A toxic goiter is one characterized by hyperthyroidism, or in the case of a diffuse toxic goiter with exophthalmos, possibly a toxic dysthyroidism.

From "Principles and Practice of Surgery" by W. Wayne Babcock (Lea & Febiger).

# PERFORATED ULCER OF ESOPHAGUS FOLLOWING A BURN

L. M. RANKIN, M.D.

Chief of Service, Delaware County Hospital

UPPER DARBY, PENNSYLVANIA

IN 1842, Curling first described as a clinical entity an ulcer of the duodenum following a burn. Ten years before Dupuytren, according to Maes, had mentioned an ulceration of the intestine in patients who survived the immediate effects of a severe burn. Although it has been one hundred years since Curling brought out the relationship between a burn and an ulcer of the duodenum, the etiology of the ulcer is still unsolved. Curling's theory as to the etiology of these ulcers is rather interesting and ingenious when one considers the limited medical knowledge of 1842. He believed that the enlarged and infiltrated glands of Brunner was an act on the part of the glands to compensate for the suppressed dermal exhalation, brought about by the sudden arrest of the important functions of the skin. The hyperactivity and irritation of the glands leads to inflammation, ulceration and sometimes perforation. This more or less explained the specific localization of the ulcer. He also believed that this theory was proved by the fact that the ulcer, if not fatal, goes on to recovery when the functions of the skin have been re-established. The trouble with Curling was that he failed to consider those cases in which the ulcer did not develop until the burned areas of the skin were healed or were progressing satisfactorily toward recovery.

Since Curling's time there have been more than thirty different theories as to the cause of the ulcer, nearly as many theories as observers. The most popular among this large group are: (1) Action of the burn toxin; (2) stasis due to blood concentration; (3) stasis due to low blood

volume; (4) adrenal theory; (5) embolic theory; (6) septic theory; (7) hypothalamus theory; (8) autonomic theory, and (9) nutritional disturbance. Of all the theories advanced, not one has been satisfactory and the process that takes place is still unsolved.

Maes states that "the concensus of modern opinion regards the toxemia of burns rather than the circulatory disturbance, as responsible for the production of the associated duodenal ulcers." Such ulcers are more frequently found in children than adults and, since toxemia is more marked in children, may help to explain and prove the toxemia theory. The ulceration, as Curling described it, is of an acute character and has been known to occur within eighteen hours after the injury. Maes states that "Curling's ulcer is very largely an unknown lesion. If it is mentioned at all in the textbooks, the description is of a very cursory character. This is partly due to the fact that it is seldom recognized during life, partly because its incidence is variable and rather low, and chiefly because it is most frequent in children whose symptoms are notoriously vague and in whom it is easy to overlook the diagnosis of even more unusual conditions."

Although it has been over one hundred years since Curling established the sequence of burns and duodenal ulcers, there is still no uniformity of opinion as to the incidence of the lesion. Maes stated that Erickson found them in two of twenty-eight fatal cases, that Ronchesi found them in one of 348 cases, and that Fenwick stated that they are present in 6.2 per cent of all deaths from burns.

Harris, with an experience of 567 cases and 138 deaths over a twelve-year period, found only one case. Levin found only two

woman with perforation of the esophagus on the fourth day after admission and who had been admitted because of severe



FIG. 1. Lower end of esophagus and stomach showing perforation of ulcer of esophagus.

cases in 12,000 autopsies. Friedenwald, Feldman and Zinn stated that "a few instances of peptic ulcer of the esophagus have been described in children. Spiegelberg and Merir observed fatal hemorrhages in two infants, aged five and six years, and Dorn reports a similar outcome in a female, aged five months, due to an ulcer situated just above the cardia."

According to Stewart, chronic peptic ulcer of the esophagus was found in one out of 10,000 autopsies and Chevalier Jackson, in 1929, using the esophagoscope, found twenty-one active ulcers and sixty-seven scars in 4,000 cases.

A search of the literature revealed only one case of a perforation of the esophagus following a burn. This was a

burns of the back and buttocks and which resulted in death. This was reported by Robinson in the *British Medical Journal* of April 3, 1943. The following case, therefore, is of interest not only because of the nature and type of case, but because of the extreme rarity of the condition. I am, indeed, aware of the pitfalls of reporting single cases, but I think I am justified under the circumstances.

#### CASE REPORT

A boy, aged four, was admitted to the surgical service at Delaware County Hospital on October 12, 1940, suffering with second degree burns of both thighs, buttocks and lower abdomen. Two days before, while playing with his brother, he sat down accidentally into

a basin of hot water. He was taken to the accident ward of the hospital, where he was seen by the chief resident physician and the burns were treated with tannic acid jelly. Since there was no bed available, he was not admitted but was sent home with instructions to the parents to consult their family physician the next day and bring the child to the surgical clinic on Saturday morning, two days later. These plans were followed and the mother brought the child to the surgical clinic on Saturday morning, October 12, 1940, and, since there was a bed available, the child was admitted to the surgical ward around 11:30 A.M. On admission the child was not acutely ill. There was a slight elevation of temperature (100°F.) and the burned areas were in very good condition. The prognosis seemed very good. About the middle of the afternoon, the child cried out as if suffering from a sudden acute pain and it was necessary to give codeine by hypo to control some of the pain. The general condition of the child gradually grew worse in spite of everything we could do and died around 5:20 P.M. Autopsy by Dr. A. D. Waltz revealed a perforated "Curling's" ulcer of the esophagus with hemorrhage.

## SUMMARY

1. Ulcer of the esophagus following burns is extremely rare.
2. Perforated ulcer of the esophagus following burns is even more rare than an acute ulcer.
3. A case of perforated ulcer of the esophagus with hemorrhage occurring in a child and causing death is hereby reported.
4. Although none have been treated surgically, the only hope for the patient lies in immediate operation.

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## BRONCHOCOLIC FISTULA

RUSSELL BUXTON, M.D.

AND

RACHELLE L. KURMAN, M.D.

Surgeon in Charge, Elizabeth Buxton Hospital

Assistant Surgeon, Elizabeth Buxton Hospital

NEWPORT NEWS, VIRGINIA

A SEARCH of the literature for bronchocolic fistula revealed but one case which occurred in Vienna in 1936, although about sixty cases of bronchobiliary fistula were found. Poverty of such material in the literature merits the reporting of the following case of bronchocolic fistula.

### CASE REPORT

This nine year old, colored, male child was admitted to the hospital May 14, as an emergency case complaining of severe abdominal pain with nausea, vomiting and a temperature of 102°F., pulse 120 and respirations 20. The family history and past history were negative. The patient had experienced lower abdominal pain for three days before admission and on the night before, the pain had become quite severe in the right lower quadrant with much tenderness. It is of note that the patient had taken a dose of castor oil with resulting purgation. Physical examination revealed a well developed, apparently well nourished child in acute pain and temperature 105°F. Respiratory and cardiovascular systems were normal. Examination of the abdomen revealed rigidity on the right side with pain and tenderness over McBurney's point. No further physical abnormalities were seen. Laboratory examination on the day of admission showed a trace of albumin in the urine with rare hyaline and granular casts; specific gravity 1.006; the blood picture showed a red blood count of 4,660,000 and hemoglobin 93 per cent. A white blood count showed 16,800 with 89 per cent polymorphonuclear leukocytes, 7 per cent lymphocytes and 4 per cent monocytes. A diagnosis of gangrenous appendicitis with perforation was made and the patient was immediately taken to surgery.

Operation proved the diagnosis to be correct. The appendix was found gangrenous, perforated and retrocecal in position. When tension was made upon its removal, it ruptured at the

base in such a manner that it could not be removed in its entirety. No bleeding was encountered and sulfanilamide powder, 8 Gm., was placed into the iliac fossa and wound. The peritoneum was closed loosely after one Penrose and one cigarette drain had been inserted. Subsequent pathological examination reported an appendix 4 cm. in length with serosa granular and covered by fibrinous exudate. On section, the wall was discolored. Microscopically, it showed the wall to be infiltrated throughout by pus cells and the mucosa partially destroyed.

The patient was placed on sulfanilamide therapy and intravenous infusions. On the second postoperative day a laboratory report still showed traces of albumin in the urine with many hyaline casts this time, the specific gravity still 1.006. The blood showed a marked secondary anemia of 2,540,000 red blood cells with hemoglobin of 48 per cent, white blood count up to 17,400 (though this may be relative) with 83 per cent polymorphonuclear leukocytes, 15 per cent lymphocytes and 2 per cent monocytes. Blood sulfanilamide was 5 mg. A blood transfusion was given. The temperature remained elevated up to and around 104°F. Ten days after operation, the anemia was still seen with red blood count of 2,620,000, hemoglobin 28 per cent, white blood count, however, was down to 7,750 with a normal differential. Urine was negative; the temperature had dropped to around 101°F. Sulfanilamide was stopped the next day because of the anemia. A transfusion was given. In the next two weeks the patient's temperature continued a septic course with 101°F. as a base line and a rise every evening. Drainage persisted and the patient was placed on sulfathiazole. No response was seen, however, and it was discontinued after five days. On June 11, 1941, the twenty-eighth postoperative day, after the temperature had seemingly subsided, it again rocketed up in four hours to 105.4°F. with the patient coughing, spitting and vomiting up a bloody purulent material. It was

feared that an intra-abdominal abscess had ruptured into the duodenum but physical examination and x-ray showed consolidation of

a bronchus in the right lung. From this the diagnosis of bronchocolic fistula was made. The patient was discharged on July 18th,



FIG. 1. Skiodan solution was injected into the abdominal fistula.

right lung. Sputum examination showed 4+ pus cells, numerous bacteria of all varieties, streptococci predominating and rare pneumococci. With use of postural drainage, some improvement in the patient's condition was noted but the temperature stayed up ranging from 99° to 103°F. During this period the appendiceal incision continued to drain profusely, the base of the right lung remained flat to percussion and râles were heard. On July 13, the sixtieth postoperative day, one ounce of 1 per cent mercurochrome was injected into the draining abdominal sinus and for twenty minutes the patient spit up mercurochrome tinged sputum. A fistulous tract connecting the right lower quadrant opening with lung seemed probable. On July 15th, skiodan was injected into the appendiceal fistula. An x-ray revealed a sinus tract which could be traced upward behind the liver and extending through the diaphragm delineating

improved, temperature 100.2°F. and advised to be treated conservatively at home. On April 4, 1942, the boy came to the office at which time his temperature was 98.2°F. There was still some cough present but no expectoration. Some ronchi at the right base were heard. The abdominal scar was well healed.

In contrasting this case with the other previously reported, it is of interest to note that the Vienna case started with a left pneumonia, complicated by empyema which burrowed downward into the colon, while in this instance, the suppurative process started in the appendix and burrowed its way upward into the chest.

#### SUMMARY

This case is of a nine year old colored child. On admission the diagnosis of

gangrenous appendix with perforation was made. He was operated upon immediately. His postoperative course was one of infection with elevation of temperature and severe secondary anemia. On the twenty-eighth postoperative day the patient developed a temperature of 105°F. with coughing, vomiting and spitting a purulent, bloody material. X-ray examination revealed consolidation of the base of right lung. Skiodan was injected into the appen-

diceal fistula and x-ray revealed a sinus extending through the diaphragm into the bronchus. The patient was discharged with the bronchocolic fistula still draining. Nine months later the patient had apparently recovered except for a slight cough. Two years later the child is reported to be completely normal.

FELKL, H. and MICHALEK, E. Bronchocolic fistula in a boy, 5½ years old. *Wien. klin. Wcbnschr.*, 49: 875-877, 1936.



THE most common *indication* for lobectomy is bronchiectasis. Other indications are benign and certain types of malignant tumors, lung abscess, and tuberculosis.

From "Operations of General Surgery" by Thomas G. Orr (W. B. Saunders Company).

# New Instruments

## AN IMPROVED THYROID FLAP RETRACTOR

WILLIAM P. ECKES, M.D.

Attending Surgeon, Metropolitan Hospital

NEW YORK, NEW YORK

THE retractor herewith described was devised by the author about two years ago in an attempt to obtain

sole purpose of retraction was not satisfactory since it put an additional pair of hands in the already limited operative

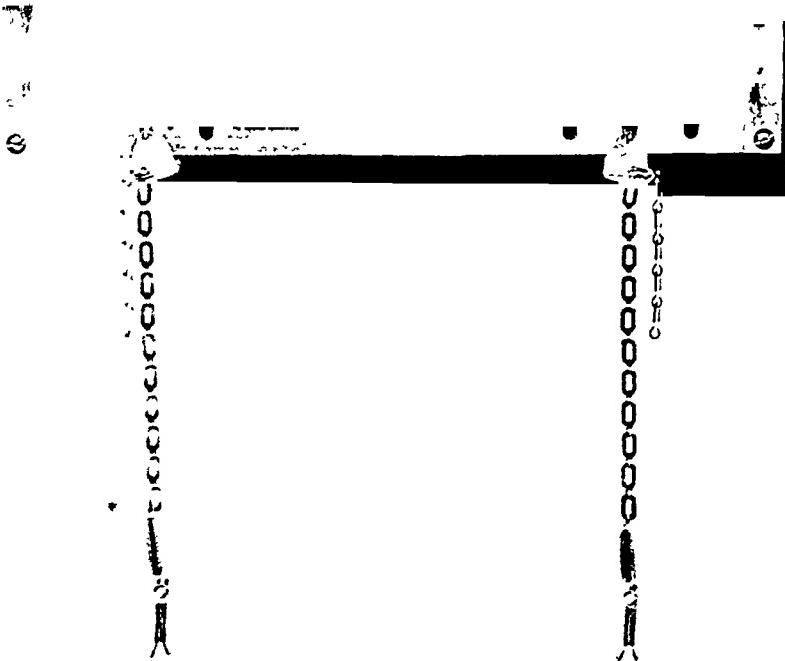


FIG. 1. Complete retractor showing parts.

constant adequate and flexible mechanical retraction of the superior skin flap in the customary collar incision employed for thyroidectomy. Available retractors were found to be unsatisfactory for a number of reasons, the chief one being that they were inflexible and further limited an already restricted operative field. The common practice of retraction by means of an Allis clamp held by an assistant presented the disadvantage of keeping one of his hands occupied,—thus decreasing his efficiency. Employment of a second assistant for the

field. Another alternative of retraction by means of an Allis clamp held by a second one attached to the anesthetist's screen was likewise not satisfactory since it did not give adequate retraction, was not flexible, and presented the undesirable feature of occasionally producing necrosis in the flap at the site of application.

Bearing in mind that only too frequently devices are offered which are subsequently found to be of value in the hands of the author alone, we, therefore, purposely delayed publication in order that ours

might have an adequate opportunity to demonstrate its usefulness in the hands of other members of our staff whose critical

flexibility of retraction such as may be indicated when working on either the right or left lobe by simply shifting the clamps

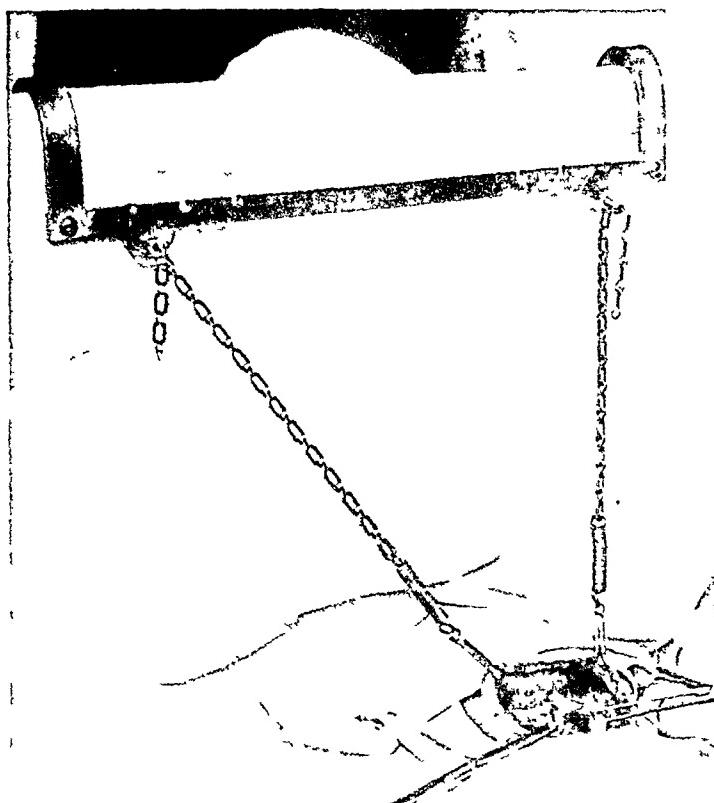


FIG. 2. Illustrating application of retractor.

comment we sought. It has been employed in well over one hundred thyroid operations, and we are presenting the instrument as a means of retraction superior to any other hitherto advanced.

The retractor consists of three parts (Fig. 1): A notched metal bar 14 inches long by  $\frac{1}{2}$  inch wide by  $\frac{1}{8}$  inch thick. This bar has two sliding clips mounted on it, and to each end of the bar are fastened two "U" shaped bars which permit hooking the device over the frame of the anesthetist's screen. Two pieces of light chain to each of which is attached a light coiled spring (having a pull of one to two pounds); to each spring, a light double hook is attached. In our retractor, these hooks were fashioned out of ordinary safety pins.

The use of screws or other parts easily lost was carefully avoided. It is readily sterilized and permits a wide range of

in the notches provided. Its application is amply illustrated by the accompanying photograph. (Fig. 2.) The cost of construction is negligible since it can be readily made up of material usually available in the maintenance department of the hospital. We found it necessary to employ a heavier anesthetist's frame than is usually found on the average operating table. Ours was made of strap iron one inch wide and  $\frac{1}{4}$  inch thick, salvaged from a discarded piece of metal furniture. This heavier frame is held in the clamps usually used for the Trendelenburg's shoulder rests.

The advantages claimed for this retractor are that it gives adequate flexible mechanical traction with a minimum of trauma, does not interfere with the operative field, is simple in construction, and can be easily duplicated at low cost from readily available materials.

# RESUSCITATOR INCUBATOR

LIEUT. COL. HARRY M. KIRSCHBAUM  
MEDICAL CORPS, ARMY OF THE UNITED STATES

DURING the past two decades there have been a number of additions and improvements in equipment for resuscitation and immediate management of the newborn infant. Most of our modern obstetrical pavilions are provided with the latest of such equipment. It has been the experience of the author to find, however, that this equipment is usually scattered throughout the delivery room and requires handling by several persons. The war emergency has limited the availability of interns, nurses and other trained personnel. This limitation affects the delivery room as well as every other department of the modern hospital, often making it necessary for the obstetrician personally to manage the newborn infant during the time he is concerned with the mother. For this reason the author set out to devise an apparatus which would concentrate all the equipment necessary for resuscitation and immediate management of the newborn and which would be so constructed as to enable the obstetrician, with little or no help, to use it without a break in sterility. After a considerable amount of experimentation and research such an apparatus was devised and is hereby described. Since it can be used as both a resuscitator and an incubator it is called the "resuscitator-incubator."

The resuscitator-incubator is a cabinet which contains a suction and pressure pump, an oxygen tank, a heating element, several drawers, tubing, electrical wiring and switches. The cabinet top is adapted as a table to convert into an incubator. The entire unit is about as large as a nursery cabinet and can occupy the space in the delivery room which is now usually set aside for the Mayo table. Figures

1 and 2 diagrammatically picture the apparatus.

The apparatus can best be presented by detailing its possible uses during a theoretical delivery: As soon as the baby's head is born the mucus can be removed from its mouth by attaching the sterile adaptor T<sub>3</sub> to the suction outlet 4. The suction machine is controlled by the foot switch 2'. When the baby is delivered it is placed on the table which consists of a galvanized screen overlying a heating unit, thermostatically controlled. The screen is, of course, covered by a sterile blanket and sheet. If the baby now needs resuscitation, direct oxygen can be given by attaching the sterile adaptor T<sub>3</sub> to oxygen outlet M and connecting to the adaptor an oxygen mask. The oxygen is delivered from the tank F and measured by a visible meter F<sub>1</sub>. The pump is controlled by an electric switch marked 2.

If it is found that the baby does not respond well, intratracheal suction can be provided as follows: Pressure on lever P<sub>1</sub> exposes a drawer by spring action which contains a sterile tracheal catheter and a sterile syringe, needles and medication. The catheter is attached to the sterile adaptor T<sub>3</sub> which in turn is attached to the suction outlet 15 and the suction machine controlled by electric switch 2'. When the catheter has removed the tracheal mucus it may be left *in situ* to deliver oxygen rhythmically thirty times a minute at a pressure of 13 mm. of mercury. This is done by transferring the adaptor T<sub>3</sub> from suction outlet 15 to oxygen outlet M<sub>1</sub> and pressing switch R. Medication can be provided at this point or at any time by using the syringe and material contained in the drawer described above. This drawer

springs back into place when the lever (foot pedal) P1 is depressed.

The apparatus can now be converted

Humidity is controlled by a humidistat constructed in the hood. Oxygen is delivered to the incubator through tube z

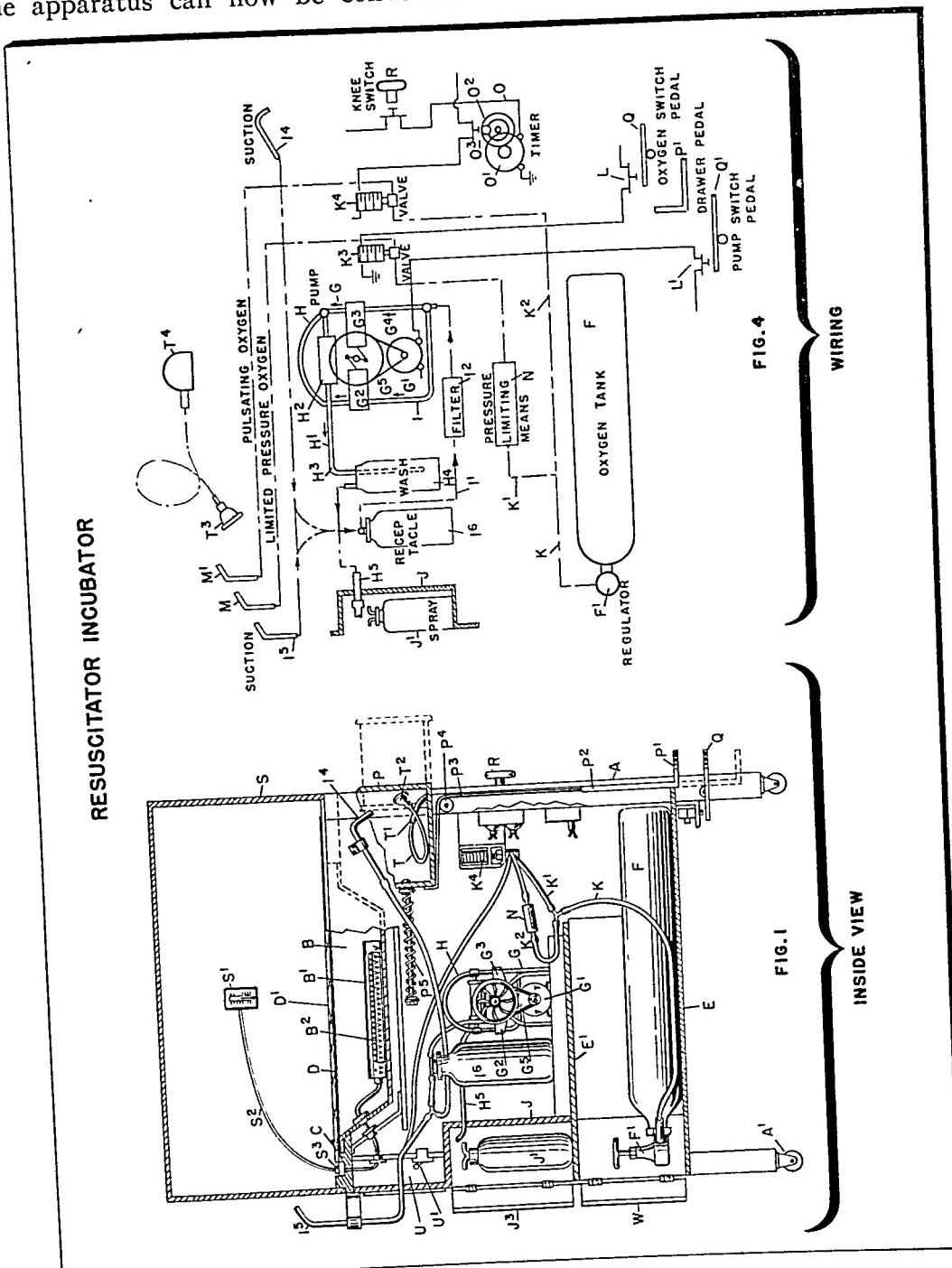


Fig. 1.

to an incubator by placing the hood, which is constructed of glass in a wooden frame, over the table top. The heat provided by resistant coils in the heat unit B is automatically controlled by the thermostat S1.

which is controlled by a switch accessible from the outside of the cabinet.

The cabinet also contains several drawers on the side of the unit for storage of sterile instruments and materials which may be

used during the delivery. On the side of the unit is a spray apparatus which makes use of the suction-pressure apparatus and can be used to spray the mother with antiseptic solution. The oxygen tank is of the large type, making it possible to transfer the entire apparatus to the nursery without the use of outside tanks. This can be done by disconnecting the electric or cord which plugs the apparatus into an ordinary electrical socket and re-connecting the apparatus in the nursery. The insulation provided in the construction of the incubator insures enough retained heat to allow for the break of electric heating current for a short period during transfer. Finally the apparatus contains an adaptor

into which may be plugged an accessory oxygen tank if necessary.

#### SUMMARY

The author has devised an apparatus for resuscitation and immediate management of the newborn infant which has the following advantages: (1) It concentrates all resuscitation and immediate management facilities for the newborn in a compact, portable and relatively inexpensive apparatus. (2) It enables the obstetrician with little or no assistance to manage the newborn infant and to resuscitate it without a break in sterile technic so that he can administer at the same time to the mother if necessary.



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## Editorial

### PRESIDENTIAL ADDRESS

CHARLES S. VENABLE, M.D.

Diplomat of the American Board of Surgery

SAN ANTONIO, TEXAS

**W**HEN I stood with the Founders of this Association in San Francisco I never dreamed that I would be the successor to such predecessors as Kellogg Speed, Edward Gilcreest, Fraser Gurd and Henry Marble.

Trust and confidence of our contemporaries, as expressed in the appointment to the leadership of an organization and a group like this, is the greatest honor that any man can have, and I feel it as deeply as that. I want you to know that this expression is cherished more than any I have ever known.

I do not like addresses, so for that reason I am going to omit the address and instead discuss one of the phases in bone surgery in which I have been particularly interested, and which has taken quite a period of time to develop, to my satisfaction at least. I hope there may be some help in it as we all go along in the same thought and in the same effort, trying to reach a goal to do the best kind of work for the greatest number of people.

I am going to discuss the absence of the excess of new bone growth, meaning callus, as we generally term it, in the presence of completely rigid fixation of bone fragments using metals without chemical irritation by internal fixation.

For a very long time—and I will quote Potts and Palmer and Orr and a good many others dealing with the influence of motion on the healing of fractures—a hematoma was considered a trellis for callus, and also an irritant for hyperemia and new capillaries.

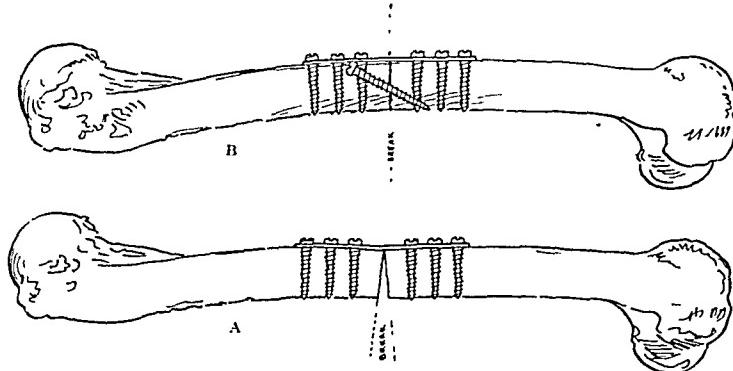


FIG. 1. A, *Mike*: Properly plated femur showing inverted v between fragments. B, *Ike*: Plated the same, but showing the posterior corticis held together firmly with transfixion screw.

Of course, during this period of both external and internal fixation, ideas have been brought forth to keep the bones fixed and immobilize the fracture. Palmer, in 1935, said that perfect immobilization to protect the matrix was essential to bone repair. I think he was perfectly right. Orr said that delayed or non-union was dependent upon a primary factor of insufficient splinting or fixation.

It has been impossible, with external fixation, to maintain that complete fixation of which I speak, so we have gone to internal fixation with plates and screws and other gadgets.

I was particularly interested in Dr. Murray's discussion and exhibition of using long wire in the fixation of fractures and to observe that those fractures which he fixed, which were perfectly immobilized by his long wire method, showed practically no excess of bone growth because of that perfect fixation.

So, if I may, I am going to introduce to you my two old friends, Mike and Ike, who always travel with me. (Figs. 1A and B.)

Mike's femur is properly plated and shows, with the weight only of the femur, much less than of the thigh and the leg below in extension, what happens due to the spring of the plate. This will happen with any kind of plate or bone graft or anything you use. All are familiar with the inverted v-shaped space between the plate and the lower margin of the femur across which new bone growth must

pass through the trellis of fibrin and early capillaries finally to make bone. So, in the event that a femur is plated in this manner, which is usual, one figures roughly a ten, twelve or fifteen week period for this union to be sufficient for weight bearing.



FIG. 2. Transverse fracture of humerus with multiple comminution of upper fragment.

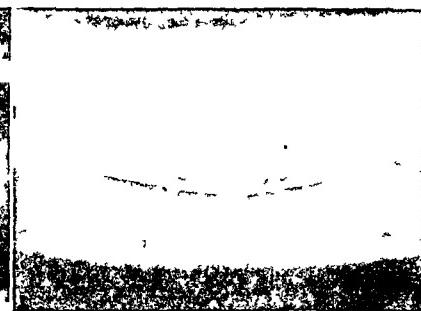


FIG. 3. Same case, fragments separately fixed to shaft with transfixion screw and plate fixing fracture and fragments over all.

In Ike, I have put what we choose to call a transfixion screw. This screw operates obliquely from the upper surface of the proximal fragment through the under surface of the lower fragment across the long axis of a transverse fracture.<sup>1</sup> Entire rigidity at the fracture site cannot be had by a single onlay splint (plate or graft) alone. Cross fixation is absolutely necessary to prevent rocking and torsion as any good carpenter will tell you. Dr. Clay Murray<sup>2</sup> and I have agreed on that principle and preached it for years. Our only difference is that he prefers to do it sideways, while I like from the above downward method best, meaning to use the pull-together force of the screw in the axis of greatest strain. With a patient on his back, that strain is from above downward and were he put to bed on his side, the strain would be sideways. No one will stand at the foot of the bed and twist the poor fellow's foot anyway. You can readily see how tightly the inferior border of the lower fragment is held against the lower margin of the upper fragment in the instance of Mike as compared with the separation in the instance of Ike. Of course, in the case of oblique fractures, transfixion must be directly across the line of the fracture. In such cases, one or two screws well placed usually are sufficient without the addition of a plate.

Our wide difference is I am convinced, and time has proven, that the entire absence of corrosive effect (electrolytic action) is essential to bone tolerance and the terminal holding factor of screws in bone

during the crucial six or eight weeks in which bone is forming across the fracture line. Dr. Murray emphasizes that the thread of the screw, the exactness of application, the dower of the tip, though it



FIG. 4.

FIG. 4. Femur deliberately shortened by osteotomy and excision of a segment with application of a transfixion screw and plate, September 28, 1942.

FIG. 5.

FIG. 5. Shows same case November 27, 1942, with firm union without callus.

touches neither sides, top nor bottom of the drill hole through which it passes, the resistant strength to strain or torsion, though minimized by exterior supports, are of first consideration, while at the same time he has the steel that he uses specially made passive in boiling nitric acid in order to create a veil of resistance against corrosion. I think my statement in 1936<sup>3</sup> that electrolytic action is the controlling factor in internal fixation of fractures is basically sound and, though met with skepticism, is proved today. No less important, as we both point out, is that early function of adjacent joints in counterbalance may be secured, which is so necessary for the physiological process of new bone growth in its early stages.

Regard for the anterior curve of the femur should always be had. Therefore, the plate must be bent to conform, instead of making the femur conform to the straight plate, which by virtue of its "spring" alone tends to separate the opposite side of the fracture to the inverted v position without contact.

What I propose to demonstrate is that with such completely rigid fixation there is very early union in which there has been a saving of some 20 to 30 per cent in time in obtaining firm union



FIG. 6.

FIG. 7.

FIG. 6. Semi-oblique fracture of lower third of the femur.

FIG. 7. Fixation with transfixion screw plus a plate, November 16, 1943.

without excess of callus, the presence of which proves local irritation.

The first two illustrations (Figs. 2 and 3) show the fracture and fixation of a humerus which was comminuted with one very large fragment free. There is a vitallium transfixion screw through the upper fragment, which was separated, and another through the fracture with a plate over all. The bend in the plate can be seen to fit the contour of the bone fragments.

Bending does not lessen the strength of plates made of vitallium because the change in molecular arrangement does not change its complete passivity. Vitallium may now be bent without fear of breaking as each vitallium piece (screw, plate or what not) is now x-rayed, because vitallium is a cast metal and each article must be devoid of flaws, while its complete tolerance in bone and tissue is the same as it has always been.

Figures 4 and 5 demonstrate a case of deliberate shortening of a femur by osteotomy and excision of a segment with application of a transfixion screw and plate for repair. The date of the operation

was September 28, 1942, while the second skiagram taken on November 27, 1942, shows that weight-bearing union had occurred in sixty days.



FIG. 8. Same case as in Figures 6 and 7  
January 16, 1944, with firm union in  
eight weeks and no excess bone  
growth.

The third case (Figs. 6, 7 and 8) shows a semi-oblique fracture in the femur in the lower third with fixation done on November 11, 1943. At that time a transfixion screw was placed in addition to a plate and there is quite a space between the fracture ends, which was due to the presence of a small marginal piece of cortical bone. In the next skiagram taken on December 15th, however, one sees quite a bit of new bone between the fracture ends yet no callus around the cortex, while on January 16, 1944, union is apparent, weight bearing was had and knee function was unimpaired.

Figures 9, 10 and 11 demonstrate another fracture of a humerus with quite a large fragment displaced mesially which was pulled into the line of fracture and fixed with one transfixion screw after which a plate was placed over all on September 14, 1942. Eight weeks later, on November 11th, it can be seen that union is complete with a moderate amount of callus on the anterior margin where the fragment was pulled into line.

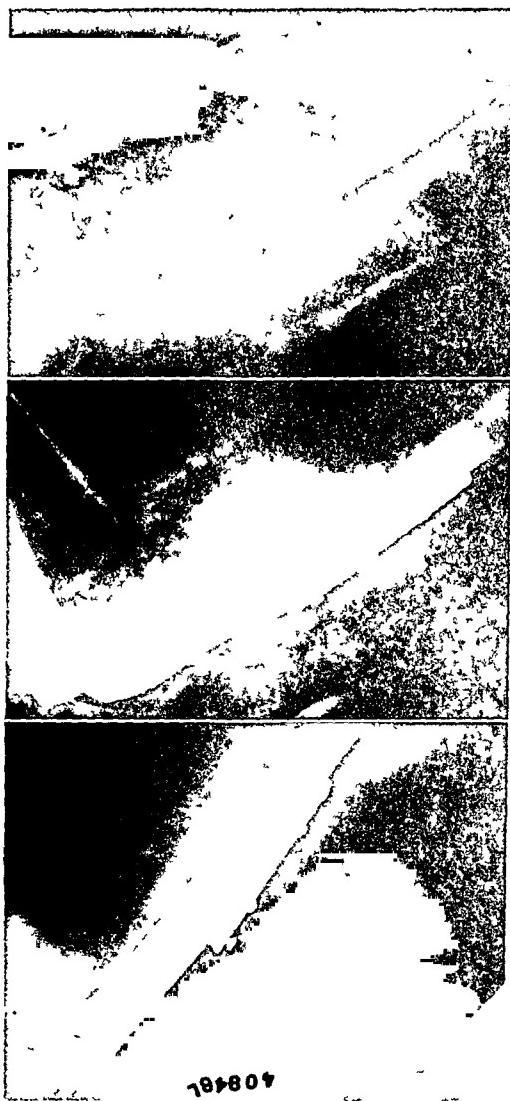


FIG. 9. Another comminuted fracture of the humerus of which large mesial fragment was displaced.

FIG. 10. Same case pulled together with transfixion screw. Plate applied pulling three fragments together, September 14, 1942.

FIG. 11. November 2, 1942, shows complete union in approximately six weeks. This patient was fifty-two years old.

## EDITORIAL

FIG. 12.



FIG. 13.



FIG. 14.



FIG. 12. Shows semi-oblique fracture, lower and middle thirds of femur in which upper fragment is fixed in adduction with flexion as result of tubercular hip in childhood.

FIG. 13. Transfixion screw is used to pull inverted v-shaped fragment into place. Plate applied over all, April 5, 1943.

FIG. 14. On July 16, 1943, same case shows perfect alignment and union maintained in this off center position. Knee function was maintained.

The interesting thing about the patient whose fracture is shown in Figures 12, 13 and 14 was that this man had a tubercular hip in childhood which became ankylosed in the usual posture of extreme



FIG. 15.

Fig. 15. Old fracture, lower third of the femur, united in extreme posterior angulation of lower fragment.



FIG. 16.

Fig. 16. Corrected position following osteotomy which is fixed by large transfixion screw and over all plate, June 23, 1942.



FIG. 17.

Fig. 17. Complete union in perfect position; weight bearing with perfect knee joint space as of August 14, 1942.

adduction with about 30 degrees of flexion. Figure 12 shows the first position of the upper fragment which had to be met at the time of the operation on April 8, 1943. It was very difficult to hold this position in counterbalance and at the same time maintain knee function. Figure 14 of August 10, 1943, shows early union and perfect position. This man was ambulatory in this extremely off-balanced posture and walking in October.

In Figures 15, 16 and 17 we have a case of osteotomy and repair for correction of a total disability of the knee due to united fracture in the lower third of the femur in angulation of about 30 degrees backward. Osteotomy was done, the position corrected and a very heavy transfixion screw (short hip screw) was used in addition to which a plate was added. Figure 15 shows the old fracture line and disability which was corrected on June 23, 1942. The next two skiagrams in anteroposterior and lateral views (Figs. 16 and 17) show union with weight bearing with complete knee function on October 14th.

I have attempted to show by this direct review of a principle, that as we have gone through the years in the discussion of fractures, we have come to recognize two factors: First, I and my associates announced some eight or nine years ago that there must be absolutely no chemical irritation from electrolytic action on any metal used in bones about fractures which would delay the healing of the fracture or would interfere with new bone growth. Second, I think we can and must do definitely what both we and our forefathers have tried to do throughout the years, which is to immobilize fractures completely. In some of the heavier, long bones it takes a transfixion screw or a bolt of some sort, transversely or obliquely through the fracture ends to prevent any motion up or down or back or forward, while adjacent joints are continued in function in counterbalance.

I believe if these two factors are kept before us and used with the simple thought in mind of complete immobilization and the complete absence of chemical irritation due to electrolysis, it can mean the difference of practically no delayed or non-unions, 20 to 30 per cent taken from the period of disability and a minimum of temporary or permanent limited function of adjacent joints, particularly of the dreaded stiff knee in fractures of the femur or of the limited shoulder or elbow function in fractures of the humerus.<sup>4</sup>

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# Original Articles

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## THE USE OF LONGITUDINAL WIRES IN BONES IN THE TREATMENT OF FRACTURES AND DISLOCATIONS

GORDON MURRAY, M.D.

Surgeon, Toronto General Hospital, University of Toronto

TORONTO, CANADA

WHILE the original application of wires longitudinally in the medullary cavities of bones was applied to the clavicle,<sup>1</sup> the principle has been found to be very effective in many other regions. It seems to be effective and to simplify the treatment of some fractures in which the results of orthodox methods are not altogether satisfactory and in which the Stader and Roger Anderson methods of treatment are least effective. In long bones with large medullary cavities such as the tibia and femur, the wire is of such small caliber that it allows too much lateral displacement of the fragments, and especially in oblique fractures of these bones it allows too much shortening to be the method of choice. However, in the clavicle, scapula, both bones of the forearm, some cases of fracture of the humerus and long bones of the hands and feet, it provides a method by which greatly improved results in these fractures can be expected. Acromio and coracoclavicular<sup>2</sup> dislocations are easily controlled by this method. Naturally, as in all procedures in which it is necessary to make an opening in the skin, the most rigid aseptic surgical technic must be observed. In our hands there has been one infection only in which it was necessary to remove the wire on this account.

It would seem that the anatomy of the skeleton was arranged so that these wires could be applied with great ease, to the areas in which they are most effective. In the humerus the wire is passed through the greater tuberosity, and vertically down the shaft the wire is placed in an extra-articular position. Passed in this way it gives excellent control of fractures of the high surgical neck or shaft. With such a wire in position the arm has been carried in a sling only,



FIG 1. Fracture dislocation of the surgical neck of the scapula and acromioclavicular joint, closed reduction, wire across joint gave excellent reduction and fixation



FIG 2. Fracture of middle finger metacarpal; fixation with wire.



FIG. 3. Fracture through neck of proximal phalanx of great toe, with 90 per cent plantar rotation; open reduction and fixation with longitudinal wire.



FIG. 4. Dislocation of interphalangeal joint of thumb of three months' duration; maintained in place by wire.

and excellent union in a good position has resulted. In the forearm with fractures of both bones, the subcutaneous olecranon, provides a very easy approach, through which to pass the wire through the



FIG. 5. Fracture index metacarpal; fixation with longitudinal wire following open reduction.

proximal and into the distal fragment. In the radius, the subcutaneous styloid process offers an easy and extra-articular approach, passing the wire through the distal and into the proximal fragment. If after reduction and fixation of the ulna with the wire, the radius can be reduced, it also is held by passing a wire. If, however, the fragments are so engaged that closed reduction is impossible, a short incision over each bone should be made and accurate reduction obtained. The wires then passed as described, provide excellent fixation which is quite easy to apply. To date, all such fractures have been fixed in plaster casts until evidence of union has taken place. In the metacarpals and phalanges, when reduction has been obtained, the wire can be passed, in the case of the metacarpal, through the distal articular end, crossing the fracture line into the proximal fragment, with the proximal phalanx flexed to an angle of about forty-five degrees. If the fracture is at the neck or near the head of the metacarpal, the wire is best passed through the distal articular end of the proximal phalanx, through its medullary cavity, crossing the metacarpophalangeal joint, through the distal fragment and well into the proximal. In fractures of the phalanges, after reduction,

the wire is passed either through the distal articular end of the affected phalanx or through the tip of the finger and across the interphalangeal joint, if necessary. In none of these fractures has



FIG. 6. Coxava; cuneiform osteotomy (Gants'); fixation with longitudinal wires; plaster cast.

there been evidence of any ill effect in the way of discomfort or disability as a result of a fine wire traversing the articular cartilages.

In fractures of metacarpals, the method of transverse fixation by Kirschner wire as described in an article by Norman<sup>3</sup> also gives excellent results.

Use of wires in a similar way offers excellent fixation in arthrodesis of interphalangeal or metacarpophalangeal joints in the hand or foot.

There is no doubt that this form of fixation, as described by the author,<sup>1</sup> is the most satisfactory from all points of view in fractures of the clavicle. In dislocations of the acromioclavicular joint, fixation by two or more wires gives a most satisfactory result with no permanent deformity. With acromioclavicular and wide coracoclavicular<sup>2</sup> separation, fixation of the acromioclavicular joint by wires also provides a very easy and effective method of allowing repair of the coracoclavicular ligaments with subsequent excellent stability and function of the shoulder girdle.

In fractures of the surgical neck of the scapula with gross deformity and projection of the axillary border of the scapula into the axilla, the best treatment is by an open reduction. A longitudinal

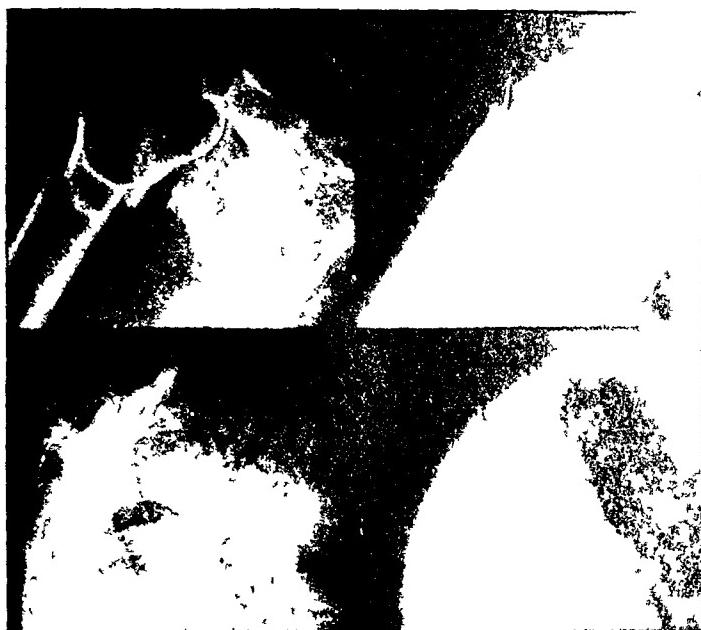


FIG. 7. High shaft fracture of humerus with eighty degrees of angulation, fixation by Kirschner wire

wire through the heavy axillary border of the scapula and up into the glenoid fragment provides excellent fixation, which is difficult to obtain and apply otherwise.

Longitudinal wires also provide an easy and excellent method of fixation of internal and external malleolar fractures at the ankle when closed methods of reduction are not satisfactory.

When an osteotomy of a long bone to correct alignment or rotary deformity is about to be done, the question of the best method of fixation of the artificial fracture arises. In Gant's subtrochanteric osteotomy to correct adduction deformity, the lower fragment tends to be displaced medially when the femur is divided across, even though oblique or semicircular incisions are made across the bone. The procedure is greatly facilitated and the fixation is adequate when a longitudinal wire is passed through the tip of the great trochanter and down the shaft of the femur. When the base of the wedge or cuneiform osteotomy has been removed, the medullary

cavity is exposed and the position of the wire can be verified. The fracture is then completed and without fear of displacement the



FIG. 8. Fracture of anatomical neck of humerus with dislocation of the head; fixation by longitudinal wire.



FIG. 9. Comminuted fracture of both bones of forearm; satisfactory result by wire fixation.

lower fragment of the femur can be abducted or rotated at will to correct the deformity. No further internal fixation of the fracture is required. Of course the usual external plaster cast is necessary to

maintain the corrected position. Similar principles can be applied in other areas.

A series of illustrative cases is reported and the x-rays demon-

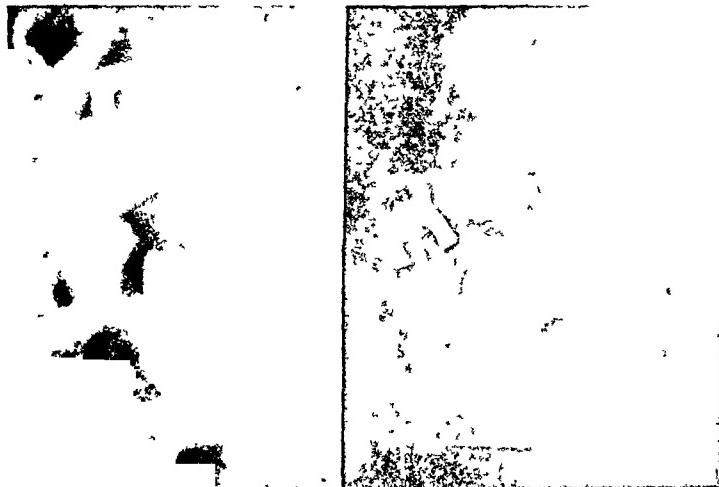


FIG. 10. Fracture of jaw (symphysis), fixation by longitudinal wire

strate the use of the wires and the end results obtained. In all there have been 154 patients treated with longitudinal wires. There was one case of infection in which a wire was applied longitudinally in the humerus for a fracture of the surgical neck. In this case the wire had been used by an inexperienced house officer, which may have been a factor in the subsequent infection. In none of the clavicle or acromioclavicular joints has there been any injury to the brachial plexus or axillary or subclavian vessels. None of the wires has drifted out of the field. From my experience in more than one hundred clavicles and acromioclavicular joints, if the wire is placed where it is intended to be, it will not migrate.

The presence of the wire across the fracture line has not impeded the rate of union of the fracture and there have been no non-unions in this series. On the contrary, in most cases these fractures have united in a shorter time than ordinarily would have been expected.

#### CONCLUSIONS

1. Longitudinal wires in bones have provided excellent fixation of certain selected fractures and in particular those fractures in which it has been difficult to obtain satisfactory fixation by external splinting either with or without skeletal pins.

2. There has been no evidence that a small or medium sized Kirschner wire which traverses articular cartilage produces any deleterious effect on the joint.

3. When wires are applied under good surgical conditions and divided to lie beneath the skin, there should be very little chance of infection resulting from their use. (One case in our series.)

4. When the wires are placed in bones, even though they cross joints, there has been no evidence of migration of the wires in this series of cases.

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#### DISCUSSION

LIEUT. COL. MARTILLUS TODD (Norfolk, Va.): In the first place I want to congratulate Dr. Murray for his very ingenious use of these wires. I think we are all familiar with the principle of using the wire, but I do not believe most of us have gone to as much trouble in developing this as he has.

It seems to me that his results in the fractured forearm particularly speak for themselves. It is a very difficult fracture to treat. I do not know how much trouble he has getting those wires in place. I suppose it is done with the fluoroscope, but in any case when he has done it, the fracture evidently cannot get out of place, and it appears to be a method of treatment that is very well worth using.

I want to call attention to one difference. Of course, there are a number of differences in the case of fractured bones in the armed services. In civilian life if a man breaks his collarbone it is of no particular importance because by any method of treatment, even though he has a big lump of bone afterward with overlapping, some shortening, some deformity or angulation, it is not of any particular consequence to a civilian. He simply has a lump on his shoulder, but his arm is very strong and he is able to carry on without any trouble.

Soldiers cannot do that. They have to wear a heavy pack, and the straps go right across the middle of the clavicle where the break is apt to be. We have had to classify for limited assignment a good number of soldiers who came to us after having broken their collarbones in civilian

life, after having been able to do their civilian work without any trouble at all. But as soldiers they are not able to wear the heavy pack; sometimes their shoulders are not strong enough to enable them to go over the obstacle course either.

If these wires can be used without incision, it is better to avoid a scar anywhere near a spot where anything could rub on it.

So I suppose the subcutaneous method of putting the wires in is preferable. There are many other comments that could be made; one is the matter of infection. Dr. Murray has had only one infection in 154 cases, which may be due to inaccurate technic on the part of a house officer. Unfortunately, I have had an infection or two myself in doing open work on bones.

I remember one particularly distressing case which had an infection in the shaft of the metacarpal bone of the ring finger, and it stiffened the metacarpophalangeal joint, so that the patient could not make a good round fist.

Those fractures also, I think, are quite difficult to treat, and if Dr. Murray is able to treat them as successfully as his x-rays indicate, I think it is a method that deserves our congratulations.

KELLOGG SPEED: Mr. President, members and guests: This device I have known for several years and have seen Dr. Murray use it. I have also used it successfully in the acromioclavicular, finger and metacarpal bones. I wish, however, to report very briefly one case, hoping that no others of you may have the unfortunate experience which I had.

A young boy with a sternoclavicular dislocation, which could not be held by ordinary means, was subjected to this procedure. It was done under general anesthesia. The Kirschner wire drill was rather cumbersome and heavy, and just as I was inserting the wire through the inner end of the clavicle into the sternum, the boy gave several convulsive coughs and jerked his body as he lay on the table. My wire was forcibly projected into the thoracic cavity and the aorta was punctured. A slow leak occurred down inside the reflexion of the pericardium. Within ten hours a heart tamponade developed and the boy passed away during my absence from the hospital.

In operating on the sternoclavicular joints or those near the great vessels, I think we should be very sure about the rigidity and quiet of the patient, and the presence of completely relaxing anesthesia.

RICHEY L. WAUGH (Boston, Mass.): In support of this treatment I should like to show a few slides which will speak for themselves. These slides cover some fractures other than the ones Dr. Murray showed. (Dr. Waugh then produced the following slides):

1. A malunion of the fifth metatarsal with about 40 degrees angulation. In this the longitudinal wire was passed up the shaft.

2. Malunion of the fifth metatarsal and non-union of the fourth and third metatarsals. This showed the marked displacement and angulation.

3. Longitudinal wires passed up the shafts.

4. In this slide a dislocation of the proximal end of the first metacarpal was shown. This was reduced by open operation and a Kirschner wire used for fixation.

5. This was a compound comminuted fracture in a patient who was admitted to the hospital about three weeks after the injury, with a large open wound, and the distal end of the tibia and the internal malleolus sloughed out. The defect was shown. The end of the tibia was approximated to the astragalus with overriding of the fibular fragments, and as the wound closed in a thin osteotome was taken and the end of the tibia and top of the astragalus were squared off, bringing these together.

Two longitudinal pins were passed up, not wires, through the calcis, the astragalus and the tibia. The final result was fusion between the astragalus and the distal end of the tibia. The foot was put up in slight equinus position and the boy is walking with a special shoe at the present time.

6. In this case we see not a simple Monteggia fracture but a rather complicated one. There were five fragments. The fragments were in a duck-bill arrangement. This patient was treated by open operation, not using a wire but a pin. The pin was inserted through the proximal fragment and then through the distal fragment, and the minor fragments were assembled around the pin and held by a circumferential wire.

GROVER WEIL (Pittsburgh, Pa.): We have found Dr. Murray's method very applicable in displaced fractures in the lower end of the radius and the ulna. Instead of using the wire we use a threepenny nail. After reposition of the displaced fragment we insert the nail into the distal end of the fragment, and the protruding end rests upon the distal fragment, holding it in very excellent position. It can be easily discarded after union is obtained. This is done with a threepenny nail instead of the wire.

FRASER B. GURD (Montreal, Canada): (Dr. Gurd showed a number of slides that were self-explanatory):

1. Monteggia Fracture—In this fracture of the ulna the wire was placed into the upper fragment, then pushed all the way out so its blunt end would run into the distal fragment; it was then pushed in by hand. That seemed to do the trick. At the end of five months there was a synostosis. The removal of the head of the radius had been deferred until this time, and a month or so ago the head and neck of the radius were removed, the synostosis was divided and removed, and the result is now fairly satisfactory.

2. This was a fresh Monteggia, which was treated in exactly the same way. It is still under treatment, and it seems as though it is holding and in a satisfactory position.

3. This showed the use of a short wire which is put in through a compound injury in just the way in which Dr. Murray suggested.

4. This was an illustration of a non-union of several years' duration, in which plating had been employed; the screw holes were seen, with the fracture. The wire was placed in through the medullary cavity up and down, and then a period between operation and apposition of the bones was allowed to lapse, about two weeks, at which time the sutures were taken out and then—and then only—were the bone ends jammed together. Although it was a four-year non-union prior to operation, union was firm and function of the limb was being recovered reasonably well within six months.

5. This was a subtrochanteric fracture of the trochanter with non-union at the end of six months. It showed the use of multiple wires following correction, similar to the way in which Dr. Murray suggested.

I should like to make one comment with regard to Dr. Murray's reference to the acromioclavicular joint, and Dr. Speed's reference to the sternoclavicular dislocation.

I urge again, as I have done before, that a method which is associated with any risk whatever should not be employed, but that in the case of the acromioclavicular the outer third of the clavicle should be removed, and in all cases in which dislocation of the sternoclavicular joint requires any interference, that interference should be removal of the medial third or half of the clavicle. I believe the results are much more satisfactory.

JOHN A. CALDWELL (Cincinnati, Ohio): Will Dr. Murray give his method of hand protection against the x-rays in this procedure?

GORDON MURRAY (closing): I should like to thank the discussers for their comments and further elaboration of the principle mentioned here.

Regarding the question of the fluoroscope, I do not work under the fluoroscope. Many of these things are done at open reduction, and the procedure is carried on according to anatomical detail. If we do use the fluoroscope, we take just a peep to see what has happened after we have done something. We do not work continuously under it. I get my hands out of the field after we have done something and see if it is all right. If it is not, we shut off the screen and do it over again and take another look.

I should like to make one further comment: Regarding the question of migration of wires, there have been some publications indicating that wires have gotten into pleural cavities and other obscene places. It is my experience that if a wire is placed where it is intended to be, it will not migrate, and in none of these cases has it changed its position in the least.

I would suggest, if it is in the pleural cavity, that somebody put it there. It did not go there by its own intelligence or otherwise.

## PHANTOM LIMB PAIN\*

ITS RELATION TO THE TREATMENT OF LARGE NERVES AT  
TIME OF AMPUTATION

LOUIS G. HERRMANN, M.D. AND EDWARD W. GIBBS, M.D.  
CINCINNATI, OHIO

THE clinical syndromes of phantom limb pain and causalgia which may follow the amputation of an extremity should be given serious consideration in this time of war since the victims of these complications are certain to present a major problem for therapy and reconstruction in the years which lie ahead. Recently, Commander James C. White<sup>1</sup> presented an excellent review of the problem of pain after amputation of an extremity and outlined the accepted methods of treatment, yet he was careful to emphasize the fact that there is no single method of treatment which is uniformly successful in eradicating such pain. He wisely added the caution that one must always bear in mind that an ineffectual or mutilating surgical procedure which is performed in the treatment of these difficult problems usually adds another psychic trauma which will eventually result in further suffering and loss of morale.

The phenomenon of the phantom limb sensations has puzzled neurologists, psychiatrists, and surgeons ever since Mitchell, Morehouse and Keen<sup>2</sup> presented the results of their experiences with gunshot wounds and other injuries of nerves during the Civil War. Very little new information has been added to the clinical aspects of the syndrome since that time. As a result of the present war, the nature and probable causes of the symptoms are being studied with renewed interest by neurophysiologists, psychiatrists, and surgeons with the hope of reducing the suffering from this dreaded complication which may follow severe injury to an extremity.

Most patients are conscious of their absent extremity after amputation. This phantom limb sensation may be present only for a brief period and usually it is not painful. Phantom limb sensation of this variety usually disappears after the patient begins to wear an artificial extremity.

\* From the Department of Surgery of the College of Medicine of the University of Cincinnati General Hospital.

In some patients, however, these sensations may take the form of severe burning or boring pain and the victims may even complain that the distal parts of the extremity are being constricted or compressed. They may also complain that a specific pain which was present in the fingers or toes before amputation persists unchanged in the phantom limb. Because of the great variation in the intensity of phantom limb sensations and the location or character of the pain, these patients usually do not receive serious consideration and the surgeon frequently assumes that they suffer from some form of psychoneurosis.

In favor of a central origin of these sensations, particularly that the symptoms might represent an obsession neurosis, are the observations that no peripheral end organs can account for the sensory impressions of posture, touch, and movement. The patient usually feels most vividly the parts of the limb which have the greatest representation in the cerebral cortex, especially the hand, index finger, toes and foot. Most patients report the phantom limb to be frozen in one position, a position which corresponds to that position in which the injured limb was last seen by the patient. Nervousness and emotional instability, which may be evident by the time the patient comes under observation in his quest for relief of pain, are thought to indicate a temperament which favors the development of an obsession neurosis.

From a clinical standpoint no one could object to any of these observations, but when they are used to exclude the possibility that peripheral irritation can be playing a part in the causation of the phantom limb pain and to prove the pure psychic origin of this condition, we must agree with Livingston<sup>3</sup> that the evidence is inconclusive. Our own observations support Livingston's contention that peripheral irritation, while by no means constituting the whole story, does represent an important factor in the syndrome of phantom limb pain. We do not believe that the symptoms are purely psychic in origin.

Bailey and Moersch<sup>4</sup> made a study of 105 patients who had had an extremity removed and they concluded that the symptoms in their patients could not be ascribed to peripheral irritation alone. They state that the mechanism of the pain was not clear and on the basis of their study they hesitated to accept the theory of ascending neuritis or peripheral irritation, but they make no mention of how the large nerves were treated at the time of amputation. They concluded, on

clinical grounds alone, that the symptoms were of central origin and stated that the evidence in their cases suggested the possibility that the phenomenon represents some form of obsession neurosis.

This interpretation of the phantom limb sensations and pain seems to represent the opinion of the majority of the students of this phenomenon. It is usually emphasized by these workers that if the syndrome came as a result of peripheral irritation, the excision of the neuroma or a re-amputation should cause the symptoms to disappear. It is the experience of most surgeons that such operative procedures usually fail to give lasting relief. Recent studies, however, seem to indicate that abnormal reflexes from the periphery to the higher centers of the central nervous system tend to become fixed or irreversible within a short time after extensive trauma to an extremity and that the subsequent removal of the original site of irritation does not always completely abolish these abnormal reflexes. The original idea of Mitchell, Morehouse and Keen<sup>2</sup> that an ascending neuritis was responsible for the pain has never been proved by histologic studies of the large nerves removed during therapeutic neurectomies (White).

#### INCIDENCE OF PHANTOM LIMB SENSATIONS

It is extremely difficult to ascertain accurately the incidence of phantom limb sensations or pain after amputation of an extremity. According to Leriche,<sup>5</sup> the syndrome is present in about 98 per cent of patients who have had an amputation of an extremity. Wier Mitchell<sup>6</sup> based his study upon ninety patients who had had an extremity removed; eighty-six of these patients experienced phantom limb sensations and fourteen had severe pain or causalgia. This represents an incidence of 95 per cent for phantom limb sensations and at least 15 per cent incidence of phantom limb pain. Bailey and Moersch<sup>4</sup> followed fifty patients who had had an extremity amputated at the Mayo Clinic and forty-three of these patients complained of phantom limb sensations or pain. This represents an incidence of 86 per cent. Our study deals only with *phantom limb pain*. Severe trauma and extensive arterial occlusion due to primary or secondary arterial thrombosis gives the greatest incidence of phantom limb pain (20 to 25 per cent) (Table 1). The average incidence of *phantom limb pain* in our series of 120 patients who survived amputation of an extremity and who were followed for an adequate period of time was only 5.8 per cent. (Table 1.)

## PREVENTION OF PHANTOM LIMB PAIN

Stimulation of the afferent pathways of large nerve trunks which have been divided certainly provokes abnormal reflexes in the spinal

LIGATION OF MAJOR NERVE TRUNKS AT TIME OF AMPUTATION JANUARY 1937 TO JANUARY 1944					
DISEASE	INCIDENCE OF PHANTOM LIMB PAIN				
	NUMBER OF PATIENTS SURVIVING AMPUTATION	NUMBER OF PATIENTS WITH ADEQUATE FOLLOW-UP STUDIES	NUMBER OF PATIENTS WITHOUT PHANTOM LIMB PAIN	NUMBER OF PATIENTS WITH PHANTOM LIMB PAIN	INCIDENCE OF PHANTOM LIMB PAIN
ARTERIOSCLEROSIS OBLITERANS WITH DIABETES MELLITUS	85	61	59	2	3.3%
ARTERIOSCLEROSIS OBLITERANS WITHOUT DIABETES MELLITUS	67	41	38	3	7.3%
INFECTION	4	2	2	0	0
EMBOLISM OR THROMBOSIS	5	5	4	1	20.0%
TRAUMA	4	4	3	1	25.0%
NEOPLASM	6	5	5	0	0
THROMBOANGITIS OBLITERANS	4	2	2	0	0
TOTAL	175	120	113	7	5.8%

TABLE I. The incidence of phantom limb pain following amputation for various diseases.

cord and Riddoch<sup>7</sup> believes that the processes of healing of the proximal end of the divided nerves evoke sensations which are projected and interpreted as if the limb were still present. He states that "during the stabilizing process of healing of the divided nerves, the sensory impulses diminish, and the sensations become correspondingly fainter with the result that the phantom limb is increasingly less obvious in outline and projection; consequently it gradually approaches the stump into which it finally disappears and fades away. If, however, the phantom limb is painful, which is usually the result of grossly abnormal conditions in the stump, the phantom may persist indefinitely and retain its original position."

We are of the opinion that the most probable primary cause of the phantom limb sensations or pain is irritation of centrally conducting axones within a neuroma or at the proximal end of a freshly cut mixed nerve. These axones formerly brought impulses to the higher centers from the part which has been removed. It is not necessary for such irritation to persist since the abnormal reflexes within the spinal cord which it provokes may cause the sensations or pain to continue even after all known afferent pathways from the extremity have been severed.

We began this study seven years ago with the primary object of preventing the irritation of afferent pathways in the mixed nerves of the extremity at the time of amputation and during the immediate postoperative period by preventing abnormal scar tissue formation or the formation of neuromas at the site of division of the large nerve trunks. It is generally agreed that the simple formation of a neuroma on a large nerve is in itself not always provocative of painful sensations. All patients with phantom limb pain upon whom we have performed secondary operations on the stump, or when we have had the occasion to study the nerves at autopsy, have shown either abnormal scar tissue formation about the nerve, neuroma formation on the proximal end of the cut nerve, or local inflammatory changes about the end of the large nerve trunks. The irritability of the neuroma, or, perhaps as Boldrey<sup>8</sup> has recently suggested, the size of the neuroma might account for the difference in reaction in the absence of abnormal scar tissue formation or inflammatory changes. The fact that Livingston<sup>3</sup> has observed several individuals with multiple amputations in whom only a single stump became painful tends to refute the idea that these patients are unduly sensitive to pain.

#### TREATMENT OF LARGE NERVES DURING AMPUTATION

There seems to be no unanimity of opinion regarding the treatment of large mixed nerves at the time of amputation but the mere fact that more than a score of methods are now being used throughout the world suggests that no single method has proved entirely successful. We believe that insufficient thought has been given to this aspect of the problem.

Boldrey<sup>8</sup> recently revived interest in this phase of the problem and presented his own method of preventing the formation of large neuromas on the ends of major nerve trunks by inserting the end of the cut nerve into the adjacent bone. His excellent summary of the other methods for treating the nerves at the time of amputation will be used here in order to conserve time and space.

“Probably the oldest preventive method, one still commonly recommended, consists of pulling down the nerve as far as it will conveniently stretch, cutting it with a sharp scalpel and allowing the proximal end to retract into the areolar tissue well above the end of the stump. Bardenheuer (1908) modified this method by turning the cut end of the nerve back and implanting it beneath the sheath of

the same nerve higher up, forming a loop. Krueger (1916) merely crushed the nerve in forceps. Sicard (1916) felt that sensory fibers only would be destroyed by 60% alcohol and recommended its use.

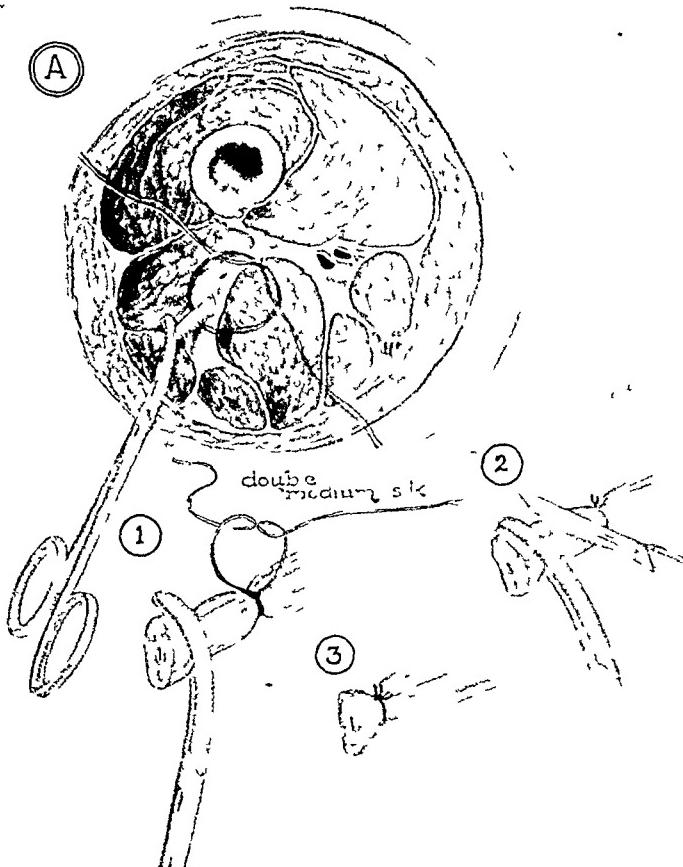


FIG. 1. The method of ligating large nerve trunks with non-absorbable suture material at the time of amputation.

Chapple (1917) turned back an epineurial cuff several millimeters in width, cut off the neuraxes and pulled down the cuff, tying it below the cut ends. Moscowicz (1918) inserted the end of the nerve into muscle. Corner (1918) excised an inverted wedge to form a 'swinging door flap,' the edges of which were sutured together. Hedri (1920) used the cautery to seal the end of the nerve and prevent the irritating effect of secretions from the wound. Huber and Lewis (1920) tied off the nerve and injected about one cubic centimeter of absolute alcohol from one to three centimeters above the site of the ligature. Stookey (1922) recommended a combination of Corner's swinging

door flap and the injection of absolute alcohol. Laewen (1925) used refrigeration. Foerster (1927) injected 5% formalin into the central stump. Beswerschenko (1929) recommended Federoff's method of

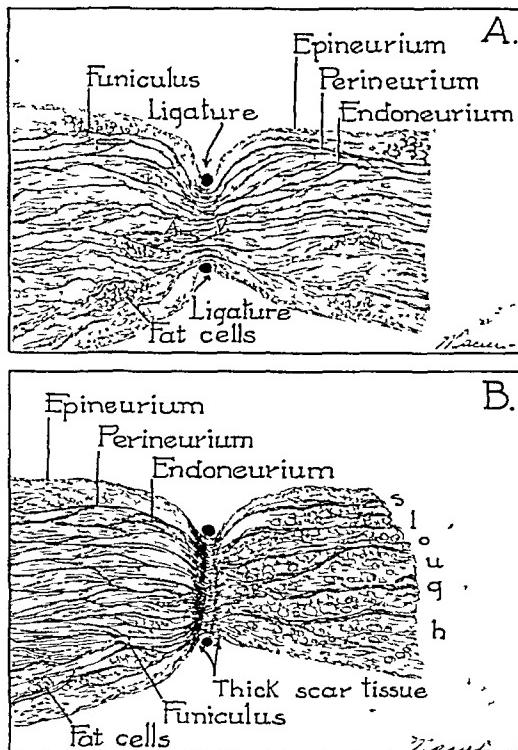


FIG. 2. Schematic representation of the effect of the non-absorbable ligature about a large nerve. A, the immediate effect of the ligature; B, the effect after one month.

phenolization of the end of the nerve and the injection of liquid phenol into the stump above the cut end. Lexer (1931) tried electrocoagulation."

In this review, however, Boldrey<sup>6</sup> made no comment as to the relative success of these various methods in the prevention of post-operative pain or phantom limb sensations. He simply makes the statement that the value of his own method of implanting the cut end of the nerve into the bone for the prevention of painful amputation neuromas cannot be stated at this time.

Our study centers around the simplest and most physiologic method of preventing regeneration of axones from the cut end of a large nerve by placing a non-absorbable ligature tightly around the uninjured nerve trunk about an inch above the site of amputation.

(Fig. 1.) Such a ligature will always control the bleeding from the nutrient artery of the large nerve and it causes a narrow line of pressure necrosis of the nerve tissues immediately beneath the ligature.

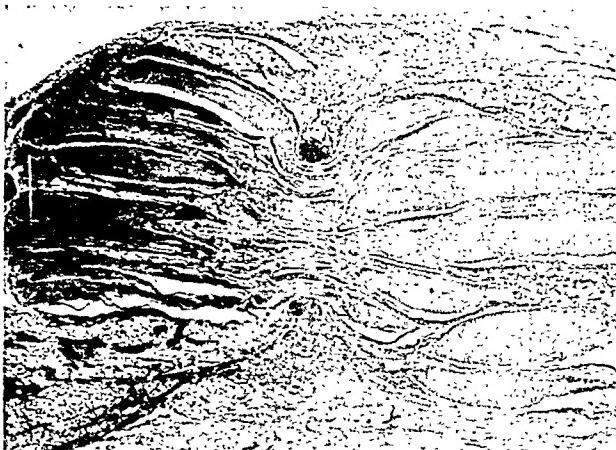


FIG. 3.

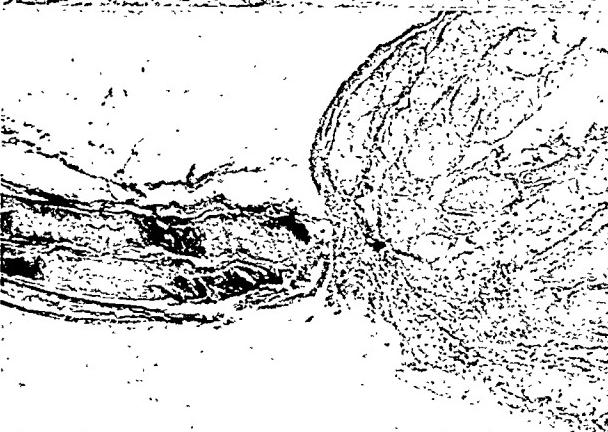


FIG. 4.

FIG. 3. Microphotograph of the sciatic nerve of a man. Specimen removed six days after a non-absorbable ligature had been placed around the nerve at the time of amputation. Note area of pressure necrosis immediately beneath the ligature.

FIG. 4. Microphotograph of the sciatic nerve of a man. Specimen removed one month after a non-absorbable ligature had been placed around the nerve at the time of amputation. Van Giesen stain showed that the epineurium was continuous with the scar tissue at the end of the nerve and no neuromas were present.

(Fig. 2A.) The regeneration of axones is prevented by the occlusion of the neurilemma sheathes; first, by the ligature itself and later, by the ingrowth of fibrous tissue (Fig. 2B.) Histologic studies made upon large nerves treated in this manner show a gradual replace-

ment of the area of pressure necrosis by fibrous tissue (Fig. 3) until finally, after about one month, the epineurium completely encases the end of the nerve except for a small area of dense fibrous tissue at the extreme end. (Fig. 4.)

DISEASE	TOTAL NUMBER	SEX		AGE DISTRIBUTION					END RESULT		
		M	F	UNDER 40	40-49	50-59	60-69	OVER 69	RECOVERED	DIED	OPERATIVE MORTALITY
		JANUARY 1937 TO JANUARY 1944 SUMMARY OF CLINICAL DATA									
ARTERIOSCLEROSIS OBLITERANS WITH DIABETES MELLITUS	110	64	46	1	4	22	45	38	85	25	22.7%
ARTERIOSCLEROSIS OBLITERANS WITHOUT DIABETES MELLITUS	88	63	25	0	3	12	25	48	67	21	23.9%
INFECTION	12	10	2	3	2	3	0	4	4	8	66.7%
EMBOLISM OR THROMBOSIS	14	8	6	1	4	1	2	6	5	9	64.3%
TRAUMA	4	4	0	1	1	0	2	0	4	0	0
NEOPLASM	6	5	1	2	0	2	2	0	6	0	0
THROMBOANGIITIS OBLITERANS	4	4	0	2	2	0	0	0	4	0	0
TOTAL	238	158	80	10	16	40	76	96	175	63	26.5%

TABLE II. Summary of clinical data.

This problem of the healing of large nerves after various methods of treatment has been studied in our laboratories by Schnug.<sup>9</sup> He found that if the large nerve was crushed before the non-absorbable ligature was applied, the neurilemma sheathes were invariably ruptured and neuromas developed in spite of the ligature. Ligatures of absorbable material were found to loosen or disintegrate before complete healing of the end of the nerve had taken place and it was his conclusion that such material should not be used to ligate large nerves at the time of amputation.

#### ANALYSIS OF CLINICAL DATA

During the seven years from January, 1937, to January, 1944, we performed 238 major amputations at the Cincinnati General Hospital and the Christian R. Holmes Hospital of the University of Cincinnati. The large nerve trunks were simply ligated with non-absorbable material at a point about one inch above the site of amputation in all of these patients. The nerves were never crushed before the ligature was applied. Of these patients 150 were males and eighty were females. The operative mortality for the entire series of

238 patients was only 26.5 per cent although a much higher operative mortality resulted among those patients with spreading cellulitis and infectious gangrene (66.7 per cent) and those with extensive arterial thrombosis superimposed upon obliterative arterial disease (64.3 per cent). The detailed analysis of these data with reference to the disease, sex, age distribution and end results is given in Table II.

## LIGATION OF MAJOR NERVE TRUNKS AT TIME OF AMPUTATION

JANUARY 1937 TO JANUARY 1944

NATURE OF PHANTOM LIMB PAIN				PHANTOM LIMB PAIN	
INITIALS AND NUMBER	AGE	SEX	DISEASE	DURATION	CHARACTER
G.M. - C.G.H. 184262	76	M	GANGRENE OF RIGHT ARM DUE TO THROMBO-EMBOLISM OF RIGHT BRACHIAL ARTERY	8 MONTHS	PARESTHESIA WITHOUT SEVERE STUMP PAIN
G.C. - C.G.H. 152904	79	M	ARTERIOSCLEROSIS OBLITERANS WITH DIABETES MELLITUS	8 MONTHS	PAIN IN TOES SIMILAR TO PRE-OPERATIVE PAIN NOT SEVERE
H.L. - C.G.H. 176457	74	M	ARTERIOSCLEROSIS OBLITERANS WITHOUT DIABETES MELLITUS	2 MONTHS	PAIN IN TOES PARESTHESIA IN PHANTOM FOOT
R.W. - C.G.H. 152139	61	M	ARTERIOSCLEROSIS OBLITERANS WITHOUT DIABETES MELLITUS	2 MONTHS	SEVERE SHOOTING PAINS IN PHANTOM FOOT
W.S. - C.G.H. 164613	64	M	ARTERIOSCLEROSIS OBLITERANS WITH DIABETES MELLITUS	2 YEARS	SHARP PAIN OCCASIONAL MILD PAIN IN PHANTOM TOES
F.C. - H.H. 380533	69	M	ARTERIOSCLEROSIS OBLITERANS WITHOUT DIABETES MELLITUS	6 YEARS	PARESTHESIA SHOOTING PAINS IN PHANTOM FOOT SIMILAR TWITCHING IN STUMP
D.J. - H.H. 430577	42	M	TRAUMA (SUPRACONDYLAR FRACTURE OF FEMUR WITH THROMBOSIS OF POPLITEAL ARTERY FOLLOWING MALPLACING OF SCREW-PIN)	1 YEAR	PARESTHESIA THROBBING PAINS IN STUMP OCCASIONAL PAIN IN PHANTOM TOES

TABLE III. Nature of phantom limb pain.

Of the 175 patients who survived the amputation of an extremity only 120 of them were followed carefully and long enough to permit evaluation of their symptoms after the operation. Of the 120 patients who had the large nerves ligated with non-absorbable material at the time of operation, 113 stated that they had never experienced phantom limb pain after the operation. Only seven patients (5.8 per cent) of the group which had been adequately studied complained of phantom limb pain. (Table III.) This represents a very low incidence of phantom limb pain in such a series of patients which includes all forms of infectious gangrene and arterial disease as the precipitating cause for the loss of the extremity.

When we analyze more carefully the seven patients of this series who complained of phantom limb pain, we find that all but one of the patients were in the sixth or seventh decades of life. All were males and five of the seven patients had gangrene due to arterial insufficiency while two had extensive arterial thrombosis in the extremity. In all seven of these patients the pain was severe enough to be disabling but in none of the patients was the pain intolerable.

## CONCLUSIONS

Irritation of centrally conducting axones by neuromas, local inflammatory changes, or by abnormal scar tissue formation about the end of the nerves may give rise to intractable pain in the phantom limb following amputation.

Placing a tight ligature about the *uninjured* large nerve trunk at a point about one inch above the level of amputation constitutes a simple and physiologic method of preventing the regeneration of axones from the cut end of the nerve.

The incidence of *phantom limb pain* in this series of 120 patients who were adequately studied after a major amputation of an extremity was highest (25 per cent) for the four patients with severely traumatized limbs but only 5.8 per cent for the entire group.

The analysis of the clinical data presented in this study indicates that the treatment of the large nerves at the time of amputation is of considerable importance in preventing the occurrence of phantom limb pain.

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## DISCUSSION

JOHN CALDWELL (Cincinnati, Ohio): The whole question of phantom limb pain and painful stump has been an embarrassing complication to every surgeon who occasionally has had to do an amputation.

Most of us have been particularly disappointed after the resection of ancient neuroma that are painful. The person who has had a painful stump for a number of years, in a large proportion of patients, is a drug addict, and between periods of addiction he is usually subjected to another neurectomy.

Consequently, any attempt to prevent these sequelae is one of the most useful and constructive problems in surgery. The explanation, as Dr. Herrmann has indicated by his complete digest of the literature from that fountainhead of peripheral nerve surgery, Mitchell, Morehouse and Keen, down to the more recent studies, has shown that it is far from a solved problem.

There seems to be a certain amount of justice in the hypothesis that after this has persisted for a time, the persistence of the pain represents a central resentment to the peripheral lesion.

I might call your attention to an analogy that is worth probably a little more than the ordinary analogy in these cases, and that is with postherpetic neuralgia, which in many ways is similar, just as persistent and just as unexplainable.

Postherpetic neuralgia is a persistent thing and does not react to any treatment, resection of the nerve and resection of spinal cord tracts are all futile for giving any relief. That has been the case with these phantom limb pains and with painful neuroma.

Consequently, this plan of prevention which has been suggested, unlike the others, has been checked to a certain extent by fairly convincing histologic studies, and is worthy of considerable interest.

ARTHUR R. METZ (Chicago, Ill.): Surgeon General Kirk, in a recent monograph on Amputations, describes the various ways of treating the nerves and concludes as follows: "There is no ideal method."

He describes the technic of Huber and Lewis which he uses. The method consists in retracting the muscle, pulling down on the nerve, and under tension, tying with plain catgut close to the muscle to control hemorrhage, and retaining the absolute alcohol which is injected with a small needle. The nerve is then severed below the ligature with a sharp knife, and retracts upward in the undisturbed intermuscular septum. Huber and Lewis showed experimentally in animals that when the nerve end is injected with absolute alcohol, the axis cylinders are killed and neuromas do not form.

In our own work, we ligate large nerves with chromic gut to control bleeding and sever the nerve with a quick oblique cut with a sharp knife. Years ago we used to inject the nerve with alcohol, novocaine, or cold salt solution, but have discontinued the practice during the past fifteen years.

The patients who have phantom pain as a rule, soon become accustomed to the sensation, and do not make it a major complaint.

The experimental work of Doctors Herrmann and Gibbs, is very convincing and is a valuable contribution, and should be given a careful trial.

E. PAYNE PALMER (Phoenix, Ariz.): In the use of a non-absorbable suture we should use a suture that is not going to result in tissue irritation. Silk, linen and cotton, will produce a certain amount of tissue reaction, but annealed steel wire will produce very little if any tissue reaction.

Therefore, in carrying out the method that Dr. Herrmann has suggested, if annealed steel wire is used you will get very little tissue reaction.

EDWARD W. GIBBS (Cincinnati, Ohio): I should like to thank Dr. Palmer for his suggestion for the use of steel wire. We have had no experience with steel wire, but we hope that others may become interested in this problem from our studies, and that through their interest the ideal method of treating these nerves may be achieved. In this manner we may minimize the appearance of phantom limb pain in those who are returning from overseas.

## KINETIC AMPUTATIONS AND PLASTIC RECONSTRUCTIONS OF FINGERS

### OPERATIVE TECHNIC AND FUNCTIONAL RESULTS

S. POTTER BARTLEY, M.D.  
BROOKLYN, NEW YORK

**T**HREE is nothing new about the procedure for kinetic amputations. It was first developed by an Italian Army surgeon by the name of Vangetti, immediately after the first Italian-Abyssinian campaign, which was disastrous to the Italians, and in which many prisoners were taken. The Abyssinian's idea of taking prisoners was to amputate their left arm or left hand and then send them back to the Italian lines. After that campaign the Italians had a large number of hand amputees.

Vangetti did the experimental work; he is credited with it. However, he never performed the operation on any human. In 1900, Cici, of Pisa, performed the first operation on a human which is reported to have been successful. After that a few sporadic cases were done.

There is not much in the literature concerning kinetic amputations, until the first World War of 1914. After that in Italy, primarily DeFrancesco, Pierra, Pelligrini and to a greater extent Putti, of Bologna, developed these methods using various kinds of motor muscle tunnels and tendon tunnels, and arthrodesis of bone ends controlled by muscles to activate the artificial hand. Immediately after the war, Sauerbruch in Germany developed a tunnel through muscle for activation purposes, which was more commonly used.

The last war gave this type of technic great impetus. Kessler, of Newark, has done more than anybody else in this country to develop the procedure, not in particular the operative technic, which was pretty well standardized by Sauerbruch for this particular method, but in the development of the artificial arm and the mechanism of the arm through technicians to make it available for this work.

The subjects for this type of operation are any individuals with an amputation of the arm to a point about four to five inches below the acromion, remembering, however, that the upper arm amputa-

tions do not give the functional results that the forearm gives, for the same reason that we have less function in the leg in amputations above the knee.

The best subject is the patient with a bilateral hand or forearm amputation. In the bilateral cases it is possible to produce artificial fingers by tube and bone grafting, if the first and second metacarpal or any of the others that can approximate against the thumb are preserved with their muscle mechanism to produce a lobster-claw hand; or the Krukenberg operation to produce a lobster-claw forearm can be done on one side and then the kineplasty on the other. This gives the best functional arrangement because the loss of sensation is most important in the hand.

However, the cosmetic appearance of these lobster-claw hands and forearms is something that should be well explained to the patient. He should see the picture and it should not be done in an individual who is sensitive to the cosmetic appearance of the Krukenberg or lobster-claw hand.

The contraindications are briefly as follows: It should not be done on any patient whom you know is the type who will not co-operate. If you cannot have intelligence and co-operation, you cannot get a good functional result. It should not be done on any patient who feels that the arm is going to enable him to do heavy work. It is not designed for heavy work and cannot be used for heavy work. The ordinary hook and strap arm is better for the individual who wishes to do heavy work.

From experience with this over a period of years, there are certain reports which have appeared in the literature. The only two worth consideration are those from Sauerbruch's clinic and those reported by Kessler in this country.

It has been reported by Ted Horn that he was able to find 403 cases out of 1,500 that have been done in Sauerbruch's clinic four or five years after World War I. Of those 403 cases he found that 83 per cent of them were using their arms daily and that the result functionally was satisfactory.

Of fourteen double amputation cases that he was able to follow in these 403, he found that ten of the fourteen were using their arms daily with good functional results, and the remaining were not using the arms.

Kessler was able to collect 276 cases in this country. This was about eight or nine years ago. Of these 276, two-thirds of that group

were wearing their kinetic arm and using them. Of that active group of two-thirds, 90 per cent were forearm amputations.

As against that type of result, Kessler surveyed 278 arm amputees who did not have a kinetic arm but the usual procedure, and he found that 12 per cent only were wearing an artificial arm for cosmetic purposes only and that only two persons were wearing a mechanical arm for functional use.

In Germany five years after the last war a review was made of 7,000 hand and arm amputations, and it was found that only 1.8 per cent of those 7,000 patients were wearing any kind of an arm which they were able to use in a functional way.

I think the quickest and best way to present the operative technic and some of the functional results is by a motion picture film.\*

For the forearm there is a variation in the operative technic. The variation is this: We do not make any attempt to close the plastic operation by skin under cutting, but we apply a half-thickness skin graft for closure. Also, in the forearm we do not make deep muscle tunnels, only about one-third of the circumference of the muscle. This is done to produce satisfactory healing of the plastic procedure.

This matter is a little dramatic, and it probably is not as good as it seems. On the other hand given an individual with an arm amputation you start from zero, and therefore you cannot lose anything. If the indications are met, the functional results are very satisfactory; but like most of these procedures if the indications are not met, the functional results are not satisfactory.

\* The author showed the film referred to. It was for the operative technic for the upper arm.

## UNUNITED FRACTURES OF THE CARPAL SCAPHOID\*

PRELIMINARY REPORT ON THE USE OF VITALLIUM REPLICAS  
AS REPLACEMENTS AFTER EXCISION

RICHEY L. WAUGH, M.D. AND LOUIS REULING, M.D.  
BOSTON, MASSACHUSETTS

**D**ESPITE the different methods followed in the treatment of fractures of the carpal scaphoid, a considerable number of these fractures, especially those through the waist or through the proximal portions of the bone, fail to unite. Cutler estimates that this failure of union occurs in 30 to 40 per cent of all cases of fractures of the carpal scaphoid. The end result of such non-union is usually a chronic deforming arthritis with serious and permanent loss of function of the wrist.

Speed has emphasized the rather peculiar blood supply to this bone and its relation to non-union. He refers to the work of Obletz and Halbstein who examined 297 carpal naviculars from cadavers and found that in one out of seven there were no arterial foramina proximal to the constricted mid portion or waist of the bone. Normally, the blood supply is from two arterioles, one entering the tuberosity; and the other, a larger one, entering the middle of the bone to give off proximal and distal branches. These vessels although penetrating the bone are not considered true nutrient arteries.

Interference with these avenues of blood supply which so often occurs in fractures of the carpal scaphoid is believed to explain its predisposition to post-traumatic necrobiotic changes and frequency of delayed union or pseudoarthrosis. Compere and Banks point out that avascular necrosis of the carpal scaphoid is second in frequency only to the head of the femur. They state that fractures through the waist of the carpal scaphoid result in necrosis of the proximal fragment in about one-third of all cases.

Johnson studied the healing processes in experimentally produced fractures of the carpal scaphoids in dogs; he has shown that these bones although of the cancellous type, heal more slowly than larger bones. According to Speed, most of the surface of the bone is

\* From the Surgical Service, U. S. Marine Hospital, Boston.

covered with smooth hyaline cartilage except for the rough ridge passing obliquely across the dorsal surface from the tuberosity to the lateral side of the medial surface of the base, where the carpal

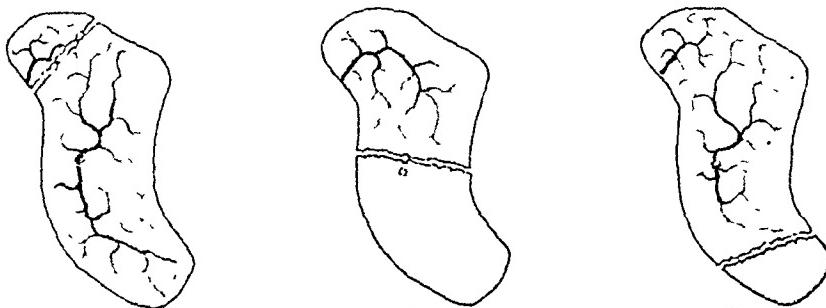


FIG. 1. Blood supply to carpal scaphoid (Cave after Lexer): Fracture site (1) tuberosity, (2) waist, (3) proximal third.

ligaments are attached. The actual repair of a fracture of the carpal scaphoid, therefore, is never by subperiosteal callus but by strictly interfragmental osteogenesis which proceeds very slowly even under the most favorable conditions.

It is generally agreed that fractures of the tuberosity readily unite regardless of the character of treatment, that fractures through the waist of the scaphoid heal with adequate and prolonged immobilization; but fractures through the proximal third, particularly if fragmented, seldom unite despite all adequate measures. The cases in the latter group, therefore, are perplexing problems from the very beginning and because of the expectancy of non-union many authors have recommended radical measures, such as bone grafting or excision of the fragments, as soon as the injury is sustained.

Certain anomalies, particularly the most common one, the bipartite scaphoid, must be considered in making a diagnosis of a recent or ununited fracture. The division plane of a bipartite bone is usually transverse and situated in the middle portion. Usually the roentgenogram shows a clear space between the portions with the edges regular and smooth. However, in the presence of a local deforming arthritis, the interspace may not be so clear and to differentiate a bipartite bone from an old fracture followed by pseudoarthrosis may be exceedingly difficult. In such instances, a negative history of trauma and similar roentgenological findings in the other wrist may be deciding factors in the diagnosis.

Errors in diagnosis resulting in delayed recognition of the fracture, combined with incomplete reduction and inadequate and

insufficiently prolonged immobilization of the fracture, are most common and no doubt account for the majority of cases of non-union. Perhaps the most frequent example of an ununited carpal



FIG. 2. Roentgenogram showing bipartite carpal scaphoid, bilateral.

scaphoid fracture is an injured wrist erroneously diagnosed without the aid of a roentgenogram as a sprain and treated without benefit of immobilization.

The actual development of non-union or pseudoarthrosis usually indicates a series of regressive phenomena, i.e., delayed union, non-union or frank pseudoarthrosis, aseptic necrosis, cystic degeneration and terminal deforming arthritis involving the radiocarpal articulation. In this connection it should be recalled that scaphoid osteitis with osteoporosis and atrophy, due to fracture, is known as Preiser's disease. From the standpoint of function, cases of pseudoarthrosis have been reported in which the function of the hand was little if any impaired and the patient apparently unaware of the defect. In such instances, however, a careful examination usually shows some limitation of motion of the wrist and some loss of power of the hand. A certain number of these cases of pseudoarthrosis remain asymptomatic only until the advent of another injury to the same wrist. This injury often is very insignificant in character and clinically considered merely a sprain of the wrist. Such cases are usually very resistant to conservative measures of treatment even with prolonged immobilization and present a most difficult therapeutic problem.

Considerable difference of opinion exists in regard to the treatment of ununited fractures of the carpal scaphoid. The character of treatment has varied from the most conservative measures, such



FIG. 3. Roentgenogram showing fracture of carpal scaphoid; A and B, before operation; C and D, after operation; (vitallium prosthesis replacement after excision).

as prolonged immobilization, to the most radical excision of all fragments or even excision of the entire proximal row of carpal bones. Briefly, the present concepts of treatment for ununited fractures of the carpal scaphoid may be stated as follows:

1. Prolonged immobilization, provided that the fragments are in a satisfactory position as recommended by Bohler, Soto-Hall and Haldeman, Speed and Bristow.
2. Multiple drilling of the fragments as recommended by Schnek, Steindler, Soto-Hall and Haldeman and Speed.
3. Bone pegging or grafting operations as advocated by Adams and Leonard, E. H. Smith, Murray, Burnett and others.
4. Excision of one or both fragments or even excision of the entire proximal row of carpal bones as advised by Cravener and McElroy, Davidson and Horwitz, Cotton, Hirsch, Cutler and Gurd.
5. Fusion of the scaphoid with the capitate and lunate as advised by Thornton.
6. Arthrodesis of the wrist as recommended in some cases by Smith-Petersen.

It is generally acknowledged that drilling and bone pegging or grafting operations are more likely to be successful than other methods, especially if the cases are carefully selected and the procedures carried out by experienced and skilled surgeons. Roth-

berg questions whether the satisfactory outcome in a grafting operation is due to the bone graft or to the drilling which is a necessary prelude to the insertion of the bone graft.



FIG. 4. Roentgenogram showing fracture of carpal scaphoid; A and B, before operation; C and D, after operation; vitallium prosthesis replacement after excision. (Note marked arthritic changes including radial styloid process.)

An argument against the bone grafting operation is presented by General Bristow in his article, "Some Surgical Lessons of the War": "Fractures of the carpal scaphoid have had satisfactory results if they have been diagnosed early, reduced and held fixed and protected until consolidated. If they have been seen late or if an old fracture has been revealed by roentgenographic examination, disappointing results have been obtained when they have been submitted to either drilling or grafting operations. So much has been written about successful grafting that a note or warning must be sounded: it is very much the exception for a soldier who has a fractured scaphoid which has been grafted to continue in the Army except in low category. He cannot handle a rifle. Many experienced surgeons are rapidly coming to the conclusion that this operation has no place in the treatment of a soldier."

The partial or total removal of fragments although practiced to a considerable extent in former years is not generally favored at this time. This, no doubt, is because of the resulting disturbance of the normal relationship of the radiocarpal joint combined with a tendency to radial deviation of the hand and the frequently asso-

ciated degenerative arthritis, both contributory to continued disability of the hand. Grace states that excision of one or both fragments or of all the bones in the proximal row leaves a deformed



FIG. 5. Roentgenogram showing fracture of carpal scaphoid; A and B, before operation; C and D, after operation; (vitallium prosthesis replacement after excision).

wrist with some permanent disability in the form of impaired function and frequently with pain on active use of the hand. Bohler states he has never seen a case in which the usefulness of the hand returned to normal after removal of the scaphoid bone. Adams and Leonard support these views stating "the removal either of the whole or a part of the bone is unsatisfactory to the patient as regards end function. The symptom pain is relieved but a varying degree of weakness in the wrist results."

On the other hand, Cravener and McElroy believe that "if a degenerative type of arthritis has already set in, no bone grafting or drilling will restore such a wrist to normal" and "for ancient ununited fractures with a degenerative arthritis, only removal of the proximal fragments will permit a cure."

Cotton in some instances removed the proximal fragments and reported that this procedure results in the relief of pain. Hirsch reports excellent results in nine cases following total removal with perfect return of function of the wrist and with no trace of radial deviation of the hand. He, however, advocates early extirpation of the bone before traumatic arthritis in surrounding bones develops.

Gurd is another advocate of excision of the carpal scaphoid for delayed union or non-union and states that he has been better pleased with the results of this form of operation than with those following either conservative treatment or the use of the bone graft.

Cutler states that while the results of the excision operation have not proved quite satisfactory, it is the treatment of choice in those cases in which reduction or union has failed and lameness of the wrist persists.

Davidson and Horwitz advise total and not partial excision of the fragments for ununited fracture, stating that the latter procedure often results in continued disability. They state, however, that excision should be done early and that if total excision is delayed, the efficiency of the procedure diminishes proportionately.

These divergent opinions indicate the difficulty in obtaining satisfactory results in the treatment of these ununited fractures. From the standpoint of uncertainty of cure, the ununited carpal scaphoid fracture is not unlike the "unsolved fracture" (of the hip) described by Speed a decade ago. Therefore, the ununited carpal scaphoid fracture might be designated the "unsolved ununited fracture of today."

We have had the opportunity at various times of performing all the above mentioned operative procedures with the exception of the intercarpal fusion as done by Thornton. Based on our experiences, we have come to the conclusion that multiple drilling and bone pegging or grafting operations are not suitable for the more complicated cases of fracture or non-union. In this group we would include the following: (1) Fresh fractures with the fragments badly comminuted and displaced, particularly those involving the proximal portion; (2) old cases of pseudoarthrosis with the fracture site either through the waist or proximal portions, and associated with local deforming arthritis, and (3) reinjury cases in which the clinical symptoms and the disability persist after an adequate period of immobilization.

In regard to treatment of this group of complicated cases, it would seem to us that there are but two alternatives. The first is the excision operation and the other is some type of an arthrodesing procedure. We believe the excision operation is the better. This, therefore, would be the operation of choice in the majority of these complicated cases. We should, however, bear in mind that the

excision operation, as is true in the other operative procedures, when carried out in this group of cases, is performed only with the expectation of partial relief of the symptoms and the disability.

In endeavoring to solve this problem it is natural to think of replacing the united carpal scaphoid with a prosthesis. That the replacement of a carpal scaphoid by a prosthesis is feasible is also suggested by the interesting case reported by Walker of a dislocation of a carpal scaphoid reduced by open operation. In this case, closed manipulation failed and on open operation, the scaphoid was found to be rotated 180 degrees. It was necessary to remove the scaphoid completely, after which it was replaced without fixation and full recovery followed.

At the present time metallic devices are used for the internal fixation of fractures, to correct or to prevent ankylosis and to fill skeletal defects. In addition to use of plates and screws, the more common practices, following the monumental work of Venable and Stuck, have been the use of vitallium cups in arthroplasties by Hopkins and Zuck, Smith-Petersen, Campbell, Burman and others; of vitallium ferrule caps for replacement of fragmented and displaced heads of radii by Kellogg Speed and the filling of a long bone defect with a vitallium prosthesis as successfully done by Moore and Bohlman.

A purpose of this communication is to report the use of vitallium replicas as replacements after total excision of ununited carpal scaphoid fragments in three patients. The results, while not entirely satisfactory in all three cases, are offered for what they are worth as an aid in solving the problem of the ununited carpal scaphoid fracture.

#### VITALLIUM REPLICAS

The actual use of a replica of vitallium as a replacement after excision of the fragments in cases of ununited fractures of the carpal scaphoid was premised on the belief that such a prosthesis would at least maintain normal relationship of the other bones of the wrist, prevent radial deviation of the hand and also might lessen or even prevent the untoward symptoms that frequently follow the ordinary excision operation.

The vitallium replica, used in our first patient was made from a mold of a carpal scaphoid taken from a skeleton and which was assumed to be of average size and shape. This replica was of solid

vitallium and weighed 29 Gm. Although the patient was quite satisfied with the operation and stated that his wrist was much improved, it was nevertheless believed that the prosthesis was of excessive weight and not a perfect fit.

To overcome these difficulties, hollow vitallium replicas were made which were patterned after a model scaphoid of average shape, determined from the mean of several scaphoids obtained from cadavers. These hollow vitallium scaphoids were made up in three sizes, small, medium and large and in pairs, right and left, to be kept on hand as "ready-made" replicas so as to offer some range of selection when needed by the operating surgeon. The weights of these hollow vitallium replicas, while not constant, were approximately as follows: small size, 12 Gm., medium size 14 Gm. and large size 17 Gm. For comparison, the average weight of human carpal scaphoids removed from cadavers was found to be between 4 and 5 Gm.

#### OPERATIVE TECHNIC

With the hand in full adduction and using a tourniquet, the scaphoid bone is exposed through a curved incision over the radial aspect of the wrist. The ends of the incision are curved toward the dorsal aspect of the wrist. The radial nerve and vessels and the abductor tendons of the thumb are retracted anteriorly and the extensor pollicis longus tendon is retracted posteriorly. A transverse opening is made through the capsule exposing the ununited scaphoid fragments. The fragments are then removed after which they are reassembled for inspection so as to serve as a guide in the selection of a replica of the proper size. The selected replica is then inserted in the scaphoid cavity of the wrist, care being taken to place the replica in proper position in respect to the articular surfaces of the adjacent carpal bones. The wound is then closed.

Following the operation, the thumb, hand and distal two-thirds of the forearm are immobilized in molded plaster of Paris splints with the distal phalanx of the thumb and the fingers free and with the wrist in about 30 degrees dorsiflexion, the optimum position for function. The plaster dressing is worn for about two weeks. After this the patient wears a leather gauntlet which is removed at intervals to permit physical therapy in the form of whirlpool and guided active exercises. After a few weeks, the gauntlet is removed at night and for increasingly longer periods during the day, but is worn for

several months after return to work, particularly if the work is of a character requiring considerable stress and strain on the wrist.

#### CASE REPORTS

CASE I. F. J. R., a man aged forty-one, employed as a machinist at the Watertown Arsenal, was admitted on March 19, 1942. In October, 1939, he had injured his right wrist. This was diagnosed as a "sprain" and he had been able to continue at work without any difficulty. On October 15, 1941, he again injured his right wrist and this time was again treated for a sprain and was off duty for two weeks. Since this reinjury he continued to have pain, discomfort and weakness of the right wrist and was able to do his work only with difficulty.

Examination showed a fullness or thickening of the right wrist with local tenderness and limitation of wrist motions in all directions. A roentgenogram showed an ununited fracture of the carpal scaphoid with displacement of the fragments. There was increased density of the proximal fragment and also moderate arthritic changes involving the articular surface of the radius. The styloid process of the radius showed enlargement.

Immobilization of the wrist (including the proximal phalanx of the thumb) in a plaster dressing for a period of two months resulted in no relief of his symptoms.

Operation was performed on April 21, 1942 (two and one-half years after the original injury and six months after the reinjury). This operation consisted of total excision of the fragments and replacement by a vitallium prosthesis. Convalescence after the operation was uneventful. He was able to return to light work wearing a leather gauntlet five weeks after the operation. Five months after the operation the patient was re-examined. At that time he seemed well pleased with the results of the operation and stated he had "wonderful action of the wrist" but he had noticed a "grating" in the wrist upon certain motions and he did not have much grasping power in his hand. The wrist, however, appeared normal except for a slight thickening and some general tenderness. The wrist motions were limited to about 50 per cent of normal in all ranges. The patient was followed for a further period of several months but despite the continued wrist symptoms was able to continue at work. It was nevertheless concluded that the solid vitallium prosthesis was too heavy and not of the best fit.

A second operation was done on January 20, 1943. This operation consisted of removal of the solid vitallium prosthesis and the reinsertion of a hollow vitallium prosthesis. At operation the cavity was found smoothly lined and containing about 2 cc. of clear thin viscid fluid. The solid vitallium prosthesis presented the usual bright appearance.

Convalescence following the reoperation was again uneventful and he returned to light work twenty-six days after the operation. He has been

seen at frequent intervals and there has been slow but continued improvement in his wrist. For the past year he has worked with little handicap. At the present time there is no apparent deformity of the wrist. The wrist motions are fully 75 per cent of normal in all ranges and grasping power is equal to that of his left hand.

CASE II. J. L., a man aged forty-three, employed as a plumber at the Navy Yard, was admitted on February 8, 1943. He had fallen on the outstretched left hand on January 14, 1943. Since that time he had noticed pain and swelling in the left wrist. Further questioning, however, revealed that the patient had had a "sprain of wrist" in 1916. He also admitted recurrences of the "sprain" with pain and swelling of the left wrist and on frequent occasions had noticed a grating sound in his wrist.

On examination there was swelling or thickening of the wrist and local tenderness over the region of the scaphoid. Wrist motions were limited and painful and he was unable to assume the position of full grasp with the left hand. The roentgenogram taken January 15, 1943, showed an ununited comminuted fracture of the carpal scaphoid with post-traumatic joint changes including the articular surface of the radius. The styloid process of the radius showed enlargement.

Operation performed on February 19, 1943, consisted of total excision of the fragments and replacement with a vitallium prosthesis. The larger fragments of the scaphoid were found well fixed by surrounding adhesions but the two minor proximal fragments appeared as "loose bodies."

Convalescence immediately after operation was uneventful. Follow-up of this case, however, showed continued pain and stiffness of the wrist which necessitated wearing a gauntlet but he returned to light duty two months after the operation. Check-up examination seven months later showed no apparent improvement in the wrist condition and removal of the prosthesis was advised. This was done in September, 1943. Despite the removal of the prosthesis there was no immediate improvement in the condition and the partial disability persisted. However, a recent examination April 4, 1944, showed an increase in the range of wrist motions and a better grasping power of the hand. He is now doing a heavier type of work but is still wearing the leather gauntlet.

The operation with insertion of the vitallium prosthesis in this case, therefore, is classed as a failure. Nevertheless, this man's present status, from a disability standpoint is believed better than could have been expected had total excision been done without temporary placement of a prosthesis.

CASE III. A. B., aged twenty-five, a ship's cook in the Coast Guard, was admitted on January 22, 1943. Eleven months before he had fallen and injured his right wrist. He was treated with a metal splint for about seven weeks. Since the termination of that treatment he continued to have

pain upon wrist motion. The patient also stated that at the age of nineteen he had had a fracture of the same wrist. At that time his wrist was in a cast for three months and his wrist thereafter was perfectly well until his injury in February, 1942.

Examination of the right wrist showed no apparent deformity. The wrist motions were limited and painful, flexion being limited to 60 degrees and extension limited to 30 degrees. There was tenderness localized over the "snuff box" of the wrist. A roentgenogram of the wrist showed an ununited fracture through the mid-portion of the carpal scaphoid with slight cystic degeneration and arthritic changes involving the articular surface of the radius. There was also noted an enlargement of the radial styloid process.

Operation was performed on February 22, 1943, and consisted of total excision of the fragments and replacement by a vitallium prosthesis. At operation there was no bony union, the space between the fragments was filled with fibrous tissue and there were many adhesions extending from both fragments to the adjacent carpal bones and articular surfaces of the radius.

Convalescence immediately following operation was uneventful. Two months after operation he returned to duty. At the last check-up examination on May 10, 1944, the patient stated that for the past year he had been doing his regular duty as a ship's cook. He stated that he had had no difficulty doing this work and he also had been able to engage in sports, such as baseball. His only complaint at that time was a little discomfort in his wrist with the approach of rainy weather. Examination of the wrist at that time showed no deformity other than a prominence in the volar aspect of the wrist site of the rather pointed tuberosity of the scaphoid prosthesis. This prominence was more noticeable upon forced dorsiflexion of the wrist. Wrist motions were fully 60 per cent of normal and grasping power was equal to that of the left hand.

#### CONCLUSION

The use of a vitallium replica for replacement after excision of the fragments of an ununited fracture of the carpal scaphoid is in the experimental stage. While the results to date are encouraging, sufficient length of time has not elapsed to determine whether or not the use of these vitallium replicas will be of value in solving the problem of the ununited fracture of the carpal scaphoid. A further report will be made on these and probably other cases when sufficient time has elapsed to determine the end results.

It would seem, however, that the greatest value of these vitallium replicas is in selected cases of ununited fractures of the carpal

scaphoid, such as (1) old cases of non-union, associated with local deforming arthritis, and (2) reinjury cases with symptoms persisting even after adequate and prolonged immobilization. These replicas also may prove to be of value in the treatment of fresh fractures of the carpal scaphoid when the fragments are badly comminuted and displaced, particularly those involving the proximal portion.

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#### DISCUSSION

CHARLES VENABLE (San Antonio, Texas): Since it has been known to be possible to use material that is not subjected to any chemical irritation, the irritation having been proven of course to be due to electrolytic action between the electrolyte and the material, all sorts of gadgets have been made of vitallium to fit almost any part of the body. Some of them have worked splendidly, and others do not work at all.

In this particular instance I think Captain Waugh has developed one that works and may be expected to work. I think we should resolve to the principle involved in the proposed application of different processes for different purposes of function.

In the replacement of a scaphoid the process is put into a stabilized area, and the function goes on about the prosthesis which in itself is immobile. You are not dependent, in this immediate area, upon the ligaments about the wrist joint or the tendons or the anatomical or physiological stability about the wrist joints, which must be taken entirely into consideration in making any kind of a prosthesis over a joint in expectation of stabilized function.

In the instance of the hip cap which is stabilized, the joint is stabilized and we expect and get function. In the instance of the artificial head of the radius as developed by Dr. Kellogg Speed, which is fixed, the joint is fixed. This radial head can be held and is fixed at the side of the ulna, and both pronation and supination is carried on in perfect manner. I have done a good many of them, and of course flexion and extension of the elbow is not interfered with at all.

However, if you were to switch over and undertake to make the upper end of an ulna even with the upper end stabilized onto the shaft, the elbow itself would not be quite so stable, although of a fair functional type.

If we go down into the knee, we find that the attempted prosthesis in using caps over the knee gives a loss of stability of the knee joint and function. For a period you will have a very fair function, flexion and extension; but after a while, as the fibrous tissue begins to tighten down about the joint, the motion will become more and more limited.

I attempted one or two with Willis Campbell and Carroll and two or three others with not good results because we found instability as well as a progressive limited function. You cannot cut off all the blood supply with metal and expect to have rehabilitation of the immediate attachments about the joint.

Of course, they make gall ducts and ureters and all those things, and there it does not make so much difference about stability. Probably the best one is the artificial testis, which seems to work all right.

Seriously, however, Captain Waugh is to be very greatly complimented for the detail it takes to work these out. You have to do a lot of figuring to make these gadgets fit and make them work. I congratulate Captain Waugh very much on this very original piece of work that he has done.

KELLOGG SPEED (Chicago, Ill.): Indications for replacement of the ununited carpal navicular bone might be conceivable on the basis of cosmetic, functional or anatomical requirements.

Surgical removal of the navicular alone, in my experience, gives no unhappy cosmetic evidence. After several years there may be a slight tendency for the wrist to sag slightly in radial flexion.

Removal of the ununited navicular may decrease the impaired function in the wrist caused by this lesion. This results by removing the dead bone which acts as a source of irritation and by ending the osteo-arthritis tendencies of neighboring carpal joints which set-up pain and which in turn lowers functional use. It is questionable, in view of the small yet necessary range of movement in the space normally occupied by the navicular straddling both distal and proximal rows of bones, whether a vitallium replacement of equal size would permit a full range of motion. A replica of reduced size might. My experiments on replacement of the head of the radius by vitallium caps lead me to conclude that although the vitallium surface is smooth and non-adherent, it does not prevent the formation of considerable inelastic connective tissue about the area of implantation. This tends to narrow the natural space left behind on removal of the bone and thus may eventually inhibit a normal range of motion. It is my belief that an analogy cannot be taken from the hip joint where there is a wide range of motion in all axes and where, after covering the head of the femur with a vitallium cap, there is early forced and extensive active and passive motion induced.

Anatomically, the loss of bone in the space normally occupied by the navicular, may not require resfilling to lead to equal strength and anatomical support of the proximal row of carpal bones. Interpretations of this point could be made only after several years of observation on a series of replacements successfully performed. Captain Waugh should be commended for starting this investigation.

GORDON MURRAY (Toronto, Canada): I should like to compliment Dr. Waugh on his excellent work in replacing the scaphoid. I agree that where the proximal fragment is comminuted, or where there are arthritic changes, that might be an excellent method of undertaking this problem.

However, the question of aseptic necrosis alone of one or both fragments probably in itself is not an indication for this; in other words, it is not a contraindication to bone grafting.

I have done now well over one-hundred cases of bone grafting of the scaphoid, and in over 40 per cent there is aseptic necrosis either of the proximal or both fragments, leaving out those cases of arthritis that are not grafted.

With an aseptic necrosis with grafting, in all of the cases I have obtained a revascularization of the proximal fragment and union of the fracture except in two cases. One of those was a case in which the boy took off his plaster early himself and started to work with motion, and he got a non-union. Another resulted in non-union which, on grafting a second time, got a union.

So there is only one permanent non-union in over one hundred cases, and in all those with aseptic necrosis revascularization has taken place with the most excellent functional result. Those people go back to their original jobs.

S. POTTER BARTLEY (New York, N.Y.): Along the same line of reasoning, particularly about what Dr. Venable has said, about two years ago in a boy of twenty-five I removed the astragalus and replaced it with a vitallium astragalus. His functional result for the first year was good. By that I mean he had a reasonably good range of motion without pain, and he returned to his work as a mechanic in a shipyard, which is fairly heavy work.

During the second year the motion diminished, still without much, if any pain; but at the end of two years he has lost about three-quarters of the motion of his ankle, inflection and extension, and he has lost completely his supination and pronation in the foot.

However, I would say in evaluating him at the end of two years, that the functional result, because of being able to keep the anatomical contour of the foot, I believe is definitely better at this time than that which would have occurred from astragolectomy either with or without fusion.

CAPTAIN RICHEY L. WAUGH (closing): I should like to thank the discussers for their remarks. The only word I have to say in closing is this:

You will note in one of the two patients being presented—the Coast Guardsman—that there is a prominence in the volar aspect of the wrist. This was due to the pointed process or tuberosity of vitallium carpal scaphoid. In the ones that we are having made now, that point has been taken off. It is a blunter point and with these you do not have the prominence in the wrist.

## TRAUMATIC NEUROCIRCULATORY DISORDERS OF THE EXTREMITIES

J. DEWEY BISGARD, M.D.  
OMAHA, NEBRASKA

**I**N both military and civilian practice there are encountered certain definite clinical entities which from the lack of definitive understanding have been designated post-traumatic neurovascular lesions of the extremities. In common with other lesions which reflect dysfunction of the vegetative nervous system, the signs and symptoms have a certain intangible character or a lack of concise pattern. For this reason and because the lesions follow trauma the afflicted often have failed to receive the proper and sympathetic consideration that they deserve. Too often the symptoms have been attributed to neuroses and malingering. And as a matter of fact a differential diagnosis is often difficult or impossible.

The underlying vasomotor disturbance manifests itself variously. In one group of cases the symptoms are predominantly those resulting from angiospasm, in another group, those resulting from vasodilatation and in many cases both exist simultaneously or intermittently. Immediately following most major injuries and often following minor ones varying degrees of pallor, coldness and numbness develop in the injured extremity. During World War I this condition, which came to be known as *stupeur arterielle*, was frequently observed. The condition followed woundless traumatism as well as penetrating or lacerated wounds and has been attributed to injury to the adventitia of the arteries. A simple contusion of the arm can make the hand and forearm so limp and colorless and the radial pulse so nearly imperceptible that a crushing injury to the brachial artery may be suspected. There are on record instances in which these vascular contractures have been so intense and prolonged that gangrene of the fingers or toes has resulted.

Fortunately, these phenomena are usually of short duration. They have been considered comparable to surgical shock of a limited nature; that is, shock limited to an extremity. During the last war there were many unnecessary amputations for *stupeur arterielle*. If there is not an early spontaneous release of vasospasm and recovery, novocaine injection of the regional sympathetic

ganglia should be done. Heat should never be applied to one of these ischemic extremities. This is a common and dangerous practice. It merely increases the metabolic demands upon an already inadequate circulation and thereby increases the likelihood of gangrene.

#### CASE REPORTS

An example of *stupor arterielle* is presented in the following case report:

CASE I. R. W., a man of twenty-four, entered the Hospital Department of the Union Pacific Railroad January 5, 1943, three hours after sustaining a gunshot wound of the right leg. The bullet had traversed the popliteal space. Immediately he was able to bear weight on the leg and seemed to have normal function of the leg and foot but within thirty minutes from the time of injury the leg became numb, cold, white and almost functionless. He had no pain except for a burning sensation at the site of injury. There was essentially no blood loss. On admission to the hospital, the patient was seen by a staff surgeon who made the following observation: The right leg presented a bullet wound of entrance on the mesial aspect of the thigh immediately above the condyle of the femur and a wound of exit on the lateral aspect directly opposite the point of entrance. The concavity between the hamstring muscles was obliterated but the space was not under tension. The foot and leg below the knee joint were very pale, cold and somewhat swollen, with slight but definite pitting edema. He executed all motions of the foot feebly and with difficulty. There was a stocking-like hypasthenia distal to the knee joint. Pulses at the ankle were not perceptible. The coldness, pallor, loss of sensation and of motor function increased with obvious impending gangrene of the toes and distal portion of the foot during the next twenty-four hours. The surgeon in attendance concluded that there was pressure upon the popliteal vessels and nerves from a hematoma or swelling, and so under anesthesia he explored the popliteal space and the calf of the leg through lateral longitudinal incisions. To his surprise, no hematoma or other source of pressure was found and the vessels and nerves were intact. No improvement in the circulatory status of the leg followed the operation. The patient was seen by me on the following day, at which time there was obvious gangrene of the great and middle toes and an area of superficial necrosis over the dorsum of the foot. (Fig. 1.) The distal two-thirds of the leg was cold, pale, numb and moderately edematous. On that day the lumbar sympathetic ganglia were infiltrated twice with novocaine. Following these injections there was a definite improvement in the color of the leg to the ankle and an increase in skin temperature. Following the

second injection, the pulse in the dorsal pedis and posterior tibial vessels became definitely perceptible.

Subsequently, the two gangrenous toes were amputated and the tendo



FIG. 1. Case I. A and B, note bullet wound's entrance and exit, incised wounds for exploration of popliteal space and calf, and the circulatory disturbance of the foot including gangrene of two toes.

"Achillis was lengthened for an ischemic contracture of the gastrocnemius muscle. The swelling disappeared rapidly but complete recovery of sensation was delayed for approximately six months. The gastrocnemius muscle has remained somewhat shrunken, hard and weak with very little evidence of gain in function. The skin of the foot and distal half of the leg still retains a shiny atrophic appearance. The patient walks without a limp and the leg has satisfactory but much impaired function.

There seems to be irrefutable evidence that the profound circulatory disturbance in this case resulted from profound and prolonged vascular contracture or vasospasm. It may be conjectured that an earlier release of sympathetic control of the vessels would have salvaged a more normal extremity.

The deleterious effect of the application of heat to ischemic extremities is demonstrated in Case II:

CASE II. A man of twenty-eight suffered a penetrating wound in the distal phalange of the middle finger of his right hand. A steel shaving penetrated and became buried in the pulp of the finger. He immediately experienced intolerable pain which radiated up the forearm to the elbow. The plant physician blocked the finger proximally with 4 cc. of 1 per cent novocaine containing adrenalin and removed the foreign body without difficulty. The hand was then soaked in a hot boric acid solution for twenty minutes. The patient returned the following day for a dressing. He complained of a persistence of numbness in the finger and inspection showed pallor, coldness and anesthesia from the proximal interphangeal joint distally with wrinkling and shriveling of the distal phalanx. Later the same day he was seen by me in consultation. There was obvious early ischemic gangrene of the finger which subsequently developed a line of demarkation just distal to the proximal interphalangeal joint. Amputation by disarticulation was done at this level.

A question of a mistake in the solution used originally for the anesthesia was investigated and this as a possible source of gangrene definitely excluded. The cause of gangrene can only be conjecture. The intolerable pain extending to the elbow immediately following injury suggests that angiospasm may have been a factor. The adrenalin and novocaine contributed an additional vasospastic factor. Undoubtedly, the immediate application of heat contributed to the development of gangrene because the ischemic extremity cannot dissipate heat through its circulation as it does normally and the increased metabolic demands of the tissues cannot be met by the impaired circulation. It seems likely that all three factors contributed.

Recovery from the acute state may be incomplete with the development of chronic neurocirculatory conditions. These result in certain trophic changes and contractures with and without pain; and since they are similar or identical to a group of manifestations which are considered under the inclusive term, causalgia, they will not be considered separately.

Causalgia was first described by Wier Mitchell during the Civil War. His description is so comprehensive that it may be quoted for its clinical value as well as its historical interest.

"The seat of burning pain is very various; but it never attacks the trunk, rarely the arm or thigh, and no oftener the forearm or leg. Its favorite site is the foot or hand. In these parts it is to be found most often where the nutritive skin changes are met with; that is to say, on the palm of the hand, or palmar part of the finger, and on the dorsum of the foot; scarcely ever on the sole of the foot or the back of the hand. Where it first existed in the whole foot or hand,

it always remained last in the parts above referred to, as its favorite seats.

"The great mass of sufferers described this pain as superficial, but others said it was also in the joints and deep in the palm. If it lasted long, it was referred to the skin alone.

"Its intensity varies from the most trivial burning to a state of torture, which can hardly be credited but which reacts on the whole economy, until the general health is seriously affected.

"The part itself is not alone subject to an intense burning sensation, but becomes exquisitely hyperesthetic so that a touch or a tap of the finger increases the pain. Exposure to the air is avoided by the patient with a care which seems absurd, and most of the bad cases keep the hand constantly wet, finding relief in the moisture rather than in the coolness of the application.

"As the pain increases, the general sympathy becomes more marked. The temper changes and grows irritable, the face becomes anxious and has a look of weariness and suffering. The sleep is restless and the constitutional condition reacting on the wounded limb exasperates the hyperesthetic state so that the rattling of a newspaper, a breath of air, another's step across the ward, the vibrations caused by a military band, or the shock of the feet in walking give rise to increase of pain. At last the patient grows hysterical, if we may use the only term which covers the facts. He walks carefully, carries the limb tenderly with the sound hand, is tremulous, nervous, and has all kinds of expedients for lessening his pain.

"The skin affected in these cases was deep red or mottled, or red and pale in patches. The epithelium appeared to have been partially lost, so that the cutis was exposed in places. The subcutaneous tissues were nearly always shrunken, and when the palm alone was attacked, the part so diseased seemed to be a little depressed and firmer, and less elastic than common. In the fingers there were often cracks in the altered skin, and the integument presented of all the affected part was glossy, and shining as though it had been skillfully varnished."

Often trigger points are demonstrable. The bones show much atrophy, the joints are swollen, stiff and painful. The muscles are atrophic and are or appear to be partially paralyzed. During World War I Meige and Athanassio-Benisty directed attention to the frequency of the relation of this condition to wounds of the median

and sciatic nerves in addition to injuries of the brachial plexus as described by Wier Mitchell.

In addition to the major causalgias incited by injury to the large nerves and vessels there are groups of minor causalgias which result from a great variety of lesser injuries, such as contusions, sprains, fractures, lacerations, and puncture wounds inflicted by animals. Not infrequently thrombophlebitis, especially the inflammatory type, gives rise to the syndrome, causalgia.

CASE III. M. K., a man of thirty-four, presented a migrating phlebitis of the left leg of eight months' duration. This had developed spontaneously and there had been no complete remissions. Pain and tenderness would leave one area only to develop in another. For six months there had been a superficial ulceration with weeping about the ankle. At the time of examination there was much swelling of the foot and entire leg up to the groin and there were areas of tenderness in the region of the saphenous vein above the knee joint. The skin over the dorsum of the foot and about the ankle had an atrophic glossy appearance with fissures through which serum exuded. Over this area the skin had a port wine color and the toes were alternately blanched and cyanotic. There was exquisite surface tenderness throughout the entire leg, and below the knee the leg was definitely colder than the opposite one. The dorsalis pedis and posterior tibial pulses were distinctly palpable. Exposure to cold and drying increased the pain which at times was intolerable. On occasion the patient was somewhat maniacal and asked that the leg be amputated. Skin temperature readings showed a constant large reduction as compared to the right leg but a good response or change in temperature following the immersion of the hands in hot water. The swelling of the leg diminished somewhat with bedrest and elevation but did not entirely disappear. Elevation, however, increased the pain.

The left lumbar sympathetic ganglia were injected with novocaine and there followed a prompt rise in skin temperature and complete relief of pain. The relief of pain lasted for approximately eight hours. On the basis of this clinical trial, a left lumbar sympathetic ganglionectomy was performed. The pain was immediately relieved and has not returned up to the time of this writing, three years following operation. The swelling had entirely disappeared in one week but returned to a mild degree when the patient became ambulatory and then did not entirely disappear for approximately six months. The skin about the ankle occasionally wept for the same period of time and then gradually lost the port wine color and developed a brownish pigmentation. The toes and the foot developed normal color immediately following operation and have retained normal appearance.

Both major and minor causalgias are associated with rapid demineralization of the bones in the affected foot or hand. Two members of this society, Hermann and Gurd, have contributed much to this subject. They are in agreement with others interested in this subject that the demineralization cannot be accounted for upon the basis of disuse atrophy. The loss of calcium takes place much more rapidly and completely than it does under circumstances of disuse. This fact was recognized by Sudeck who first described the condition in 1900. The atrophy occurs principally in the short bones of the carpus and tarsus and to a lesser extent in the epiphyses of the metacarpus, metatarsus, phalanges and the distal epiphyses of the bones of the leg and forearm. There is associated atrophy of the articular cartilage and periarticular structures as well as the muscles and skin of the foot or hand. In fact the changes in the bone are merely a part of the picture of causalgia as described above. Recovery from the neurovascular disturbance is accompanied by remineralization of the bone. Fontaine and Herrmann are of the opinion that recalcification is never completely achieved.

These bone and joint changes are the principal source of prolonged disability and a source of distress, long after the superficial tissues have regained normal appearance.

Sudeck's bone atrophy is seen not infrequently in association with fractures about the wrist joint but may follow relatively trivial and minor injuries as in the case that follows:

CASE IV. O. N., a physician of forty, lacerated the thenar web of the left hand and within forty-eight hours developed marked swelling of the entire hand to a level just above the wrist. Although the skin had a port wine color, there was an actual decrease in skin temperature. At no time was there evidence of infection. The wound healed by primary intention and there was no suppuration. Furthermore, at no time was there fever, an elevation in the leukocyte count or an adenitis. The swelling persisted without change for four weeks and then gradually receded during the subsequent four weeks. There were superficial manifestations of causalgia, severe pain, hyperesthesia and atrophy of the skin. Acute bone atrophy developed in all the carpal bones and the distal epiphyses of the ulna, radius, metacarpals and phalanges. Demineralization was so complete at one time that the outlines of some of the carpal bones were entirely lost and the roentgenologist expressed the opinion that there was complete destruction as the result of osteomyelitis. However, recalcification gradually took place but was incomplete. Films made two years after the injury

showed much less density in the affected bones than in the comparable ones of the right hand. (Figs. 2A, B and C.) At this time essentially normal function of the left hand had been regained.

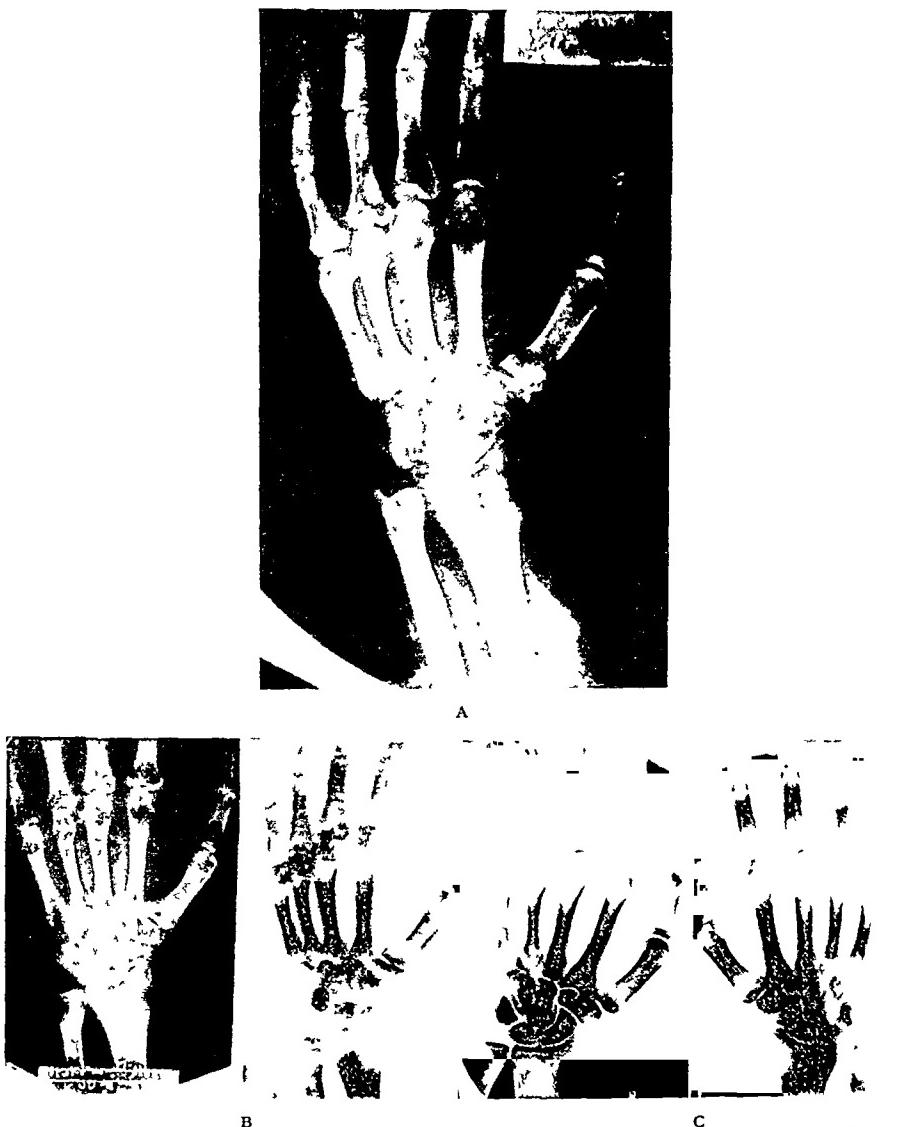


FIG. 2. Case IV. A, one month after injury, showing the moth-eaten appearance of early but advanced acute bone atrophy. B, two months after injury. Demineralization of the carpal bones has progressed to an extent that the outlines of the individual bones are indistinct. Note decalcification of the epiphyses of the long bones of the hand and fingers and of the distal radius and ulna. C, one year after injury. Compare incomplete recalcification of the left hand with the unaffected right.

This case illustrates a dangerous fallacy in the interpretation of roentgenograms. Upon the basis of roentgenograms alone it may be

impossible to distinguish this type of bone atrophy from osteomyelitis. Such findings can be interpreted only in connection with the entire clinical picture.

The disturbances in cutaneous sensation vary from extreme hyperesthesia to complete anesthesia and frequently there is paresthesia. There is also deep tenderness.

The treatment of post-traumatic neurovascular lesions varies with the individual case. The acute vascular contractures with impending gangrene are emergencies, demanding immediate efforts to relieve vascular spasm by means of novocainization of the regional sympathetic ganglia or periarterial sympathectomy. Heat should not be applied to these extremities.

Before treatment is undertaken in chronic cases a careful neurological and psychiatric study should be made in an effort to exclude compensation neuroses and hysteria. All doubtful cases, and there are many, should be looked upon as true causalgias and treated accordingly until a diagnostic therapeutic trial has proved them otherwise. To dismiss them simply as psychogenic does a great injustice to these sufferers.

Major causalgias associated with injury to major nerves such as sciatic, brachial plexus and median may be relieved by such procedures as neurolyses when the nerve is imbedded in scar, excision of neuromas when present, repair of a nerve when partially severed and by excising foreign bodies such as bullets or shell fragments in close proximity to these nerves.

Every case should be examined carefully for the possible presence of a trigger point, a discrete sensitive area or nodula. Pressure over this area is likely to excite a paroxysm of pain. Livingston, who first described these trigger points, has reported complete relief in a series of cases following either novocaine infiltration or excision of these points. I have had similar gratifying results from excision of trigger nodules in two cases, one a small neuroma in the periosteum of the ulna resulting from a blow at that point.

Minor causalgias and particularly the bone atrophy of Sudeck following fractures or other injuries may be prevented by the early institution of physical therapy and once developed this form of therapy probably shortens the otherwise long period of recovery.

Gurd has presented evidence that in cases of fractures Sudeck's bone atrophy can probably be prevented by early application of non-padded plaster casts or similar tight rigid dressings to the

extremities. This prevents the edema which may be a determining factor in this condition. In cases in which atrophy and the other neurovascular disturbances have developed, he confines the patient to bed with the limb elevated until the interstitial edema has disappeared. A silk stocking is then placed on the extremity and a plaster of Paris bandage applied. The bandage is made to cover the fourth and fifth toes, and is accurately molded to the contour of the leg. A heel or walking iron is applied to the leg cast and immediate weight bearing insisted upon. Since patients with acute bone atrophy are extremely fearful of pain from use of the extremity, much reassurance and encouragement are necessary.

In cases in which there is no definite evidence of involvement of nerves or demonstrable trigger points, or in cases of this sort in which the direct attack has failed, treatment to interrupt the sympathetic innervation of the extremity should be carried out. The simplest and most conservative method should be utilized first; that is, novocaine, pontocaine or urea injection of the stellate or second and third sympathetic ganglia for lesions of the arm, and injection of the lumbar ganglia for causalgias of the lower extremity, as devised by White, DeBakey and Ochsner. A single injection may result in permanent cure, but if only temporary relief is obtained, repeated injections may bring about a cure. If this method fails, one of two radical attacks are available: either the periarterial sympathectomy of Leriche or cervicodorsal or lumbar sympathetic ganglionectomy.

Because the patients in the more severe cases are likely to become addicted to morphine, every effort should be made to obtain early relief of pain.

Certain painful amputation stumps fall into the category of causalgia. These are stumps in which there is no evidence of an amputation neuroma and in which the skin displays evidence of vasomotor instability such as edema and red or bluish discoloration. They are principally the stumps of amputations between the knee and ankle. I have one case of this type which was entirely relieved following excision of a painful nodule in the scar which proved to be an epidermal inclusion cyst. On occasion an attack upon the sympathetic innervation may be indicated.

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#### DISCUSSION

EVERETT P. COLEMAN (Canton, Ill.): Dr. Bisgard's very excellent paper covers a great variety of pathology, extending from stupeur arteriel to the commoner and more troublesome cases of edema of the leg following fracture of the tibia.

Dr. Bisgard was kind enough to send me a copy of his paper, and in it he refers to the difficulties in diagnosing, or differentiating, rather, between cases of neurocirculatory diseases, neurosis and malingering. This is quite easy to understand, because all three conditions may occur in the same patient.

Take for example an individual who is covered by industrial insurance, or who has an insurance policy against injury. If he sustains an injury that produces rather unusual symptoms, such as more pain, more edema, more reaction around the joint than is ordinarily expected, and if under these circumstances this patient does not get well when his doctor ordinarily thinks he should, and if the doctor does not recognize the fact that certain neurocirculatory conditions are occurring, that fact soon becomes obvious to the patient. He then, because of a feeling that his condition is not understood, that his pain is not appreciated, tends to develop an anxiety neurosis based on the fear that further complications may occur and that they also will not be identified.

Furthermore, when that patient finds out, after a bit of observation, that a continuation of symptoms may bring about rather satisfactory

financial adjustments, it is very easy again to understand why, in addition to real disease, he might develop that complex commonly known as "compensationitis."

However, I would like to limit my discussion very largely to one condition that Dr. Bisgard has mentioned, that is, Sudeck's atrophy of the hand and wrist. With this I have had a little experience and a lot of trouble.

Sudeck's atrophy is supposed commonly to occur in those patients who have had a rather minor injury of the forearm or wrist. I have seen it in two cases in very old people, associated with a Colles' fracture. In each of these when the fracture was reduced perfectly, when adequate splinting was applied, each one was complicated by a rather severe bone atrophy of the Sudeck type, and the end result in each case was very unsatisfactory.

However, this condition occurs much more commonly in younger, rather middle-aged individuals, and those in whom I have seen it have all had an injury, usually a fall, with a moderately painful reaction. In these cases the pain would be sufficiently severe so as to suspect a fracture. There would be no deformity, but one would suspect a possible fracture of the lower end of the radius or one of the carpal bones. This would be ruled out by x-ray.

When this condition occurs the rather common advice given to the patient is, "It's just a sprained wrist; go ahead and use it, and if it hurts apply heat; soak it in hot water."

Dr. Bisgard brought out very nicely the disadvantages of the application of heat. We have seen in these patients within from one to four weeks after this type of treatment, the beginning atrophic changes that may occur. They will not be evident in the x-ray in one week, but they not uncommonly are visible in four weeks.

When these cases are seen later, the common experience of the patient has been that after the allegedly sprained wrist, he has more pain, swelling, edema, and then he is advised to have diathermy. His disability is lasting longer than it ought to last, so diathermy is recommended to speed up the period of convalescence, and it simply makes a bad matter worse.

Usually the patient is the one who is the first to notice that diathermy is doing harm rather than good, and he commonly quits it of his own accord.

I believe the answer—there is no real answer as yet—but I believe a definite lesson to be learned from this condition is that in any injury of the wrist, hand or forearm, which is sufficiently severe that you may suspect a fracture, and the x-ray shows a fracture does not exist, that we should bear in mind the possibility that once in a while Sudeck's atrophy does occur.

I think there is a certain type of patient in whom it is apt to occur, but time is too short to go into that now. Nevertheless, we should bear it

in mind, and routinely we should immobilize these joints and wrists as though a fracture did exist. Immobilize them completely and firmly, not for long, usually a period of seven to ten days. They should be inspected every two or three days. The immobilization should continue until all swelling and tenderness has subsided, and this ordinarily will not take long.

I believe by doing this that complications can many times (perhaps not always) be avoided. And if it does occur, I believe the early injection of novocaine in the region of the stellate ganglion, a method which I described in 1937 before the Western Surgical Association, will sometimes be of real value and will avoid the necessity of further radical surgery.

HOMER D. DUDLEY (Seattle, Wash.): I have no intention of attempting to add anything to the scientific phase with respect to injuries of the hand and the various changes occurring in the neurovascular systems of the extremities. I do want to add a point which I believe is of practical interest, and I may preface it by saying that it has been my privilege to examine several thousand injured workmen for the Department of Labor and Industries of my State, and among these a great many injuries of the hand.

During the early part of my experience in examining these patients and attempting to give the Department an evaluation of their disabilities, I became prejudiced, as I believe most of us have, in assuming that a trivial injury could not produce the disability which is often alleged.

One is often prejudiced when he examines a patient with neurocirculatory disorders, who is covered by industrial insurance or private insurance carrier; but I have seen this condition occurring in housewives, also two of my professional friends, in whom there was no liability on the part of an insurance carrier, and they had all the symptoms and associated disabilities. I have had occasion to review as many as eight such patients over a period of fifteen years, long after the claimant's award had been spent, and still had all their symptoms with only variations of relief.

In January, of this year, I reviewed a series of these cases and reported them before our local Surgical Society. I came to this conclusion:

We do not know the cause of the symptom complex "causalgia." Dr. W. K. Livingston has given us somewhat of an "out" by referring to a group classified as "causalgic states" but it does not answer the question. We still have the patients and we still have them suffering with this disability.

When by differential diagnosis true causative factors have been excluded, such as post-traumatic neuromas and known neurocirculatory lesions, then the diagnosis of causalgia may be made.

For medicolegal purposes, we should admit we do not know the cause of this disease or its cure and cease to go to court and testify to speculative and conjectural theories. Why should doctors be penalized because they

did or did not administer a certain form of treatment when the symptoms continue inevitably without relief from any form of treatment?

The insurance carriers and the Departments of Labor and Industries, who compensate workmen for these disabilities, should admit the diagnosis and treatment is not known and should give the proper aware of permanent partial disability.

**Louis G. HERRMANN** (Cincinnati, Ohio): Dr. Bisgard gave me a copy of his paper and asked if I would say a few words about the problem.

Earlier I talked about the prevention of some of these complications, and I should like to re-emphasize some of those points again.

I am sure that many of the complications which Dr. Bisgard has described can be prevented, but after they are once established, the reflexes become permanently established in the nervous system, and it is very difficult then to remove either the symptoms or the effects.

I think many of the people who have symptoms many years after an injury have them, not because of the original injury, but because of reflexes which have been set up in their nervous system, as a result of the injury.

The whole problem of post-traumatic painful osteoporosis, as Fraser Gurd, John Caldwell and I have written about many times, is still in an unsettled state. We are convinced, however, that much can be done to prevent such complications to injury. Do not allow the symptoms to go on indefinitely before adequate treatment is given. Do not consider them to be occupational neuroses or compensation neuroses, but realize that these patients have real complaints, and see if you cannot relieve them either by blocking the sympathetic ganglionated chains with novocaine, by periarterial sympathectomy or by some physiotherapeutic measures.

Secondary vasospasm is one of the important disturbances which must be recognized early because reconstruction becomes difficult after trophic changes in the muscles have occurred, or after extensive thrombosis of small blood vessels has taken place.

If you will recognize this ischemia early and consider it to be the result of high grade peripheral vasospasm, then paralysis of the sympathetic nervous system impulses by novocaine or by surgical operation will usually prevent most of these complications.

**FRASER B. GURD** (Montreal, Que.): As the essayist and as Dr. Herrmann have indicated, I have had an interest in this condition for a great many years. My specific interest commenced about 1924, and in the interval I have tried to understand the condition and have tried to learn something about it.

I was going to say none of us understand the condition; at any rate I do not understand the condition, even after having spent a lot of time trying to understand it and having read the literature which, as you know, has been almost entirely European.

Of the ninety-two reports in the literature on considerations of the subject, only three of them were in English in 1935. All the others were either in German or more particularly French.

There is the case of a man, forty-nine years of age, who fell off his bicycle on July 4, 1943. An x-ray\* was taken to prove that he did not have a fracture. He was not treated,—I was going to say “adequately.” He was hardly treated at all except for the fact that as his hand was stiff and he was complaining of it, about the middle of August manipulation under an anesthetic was carried out, and from that moment his condition became extremely grave. The hand, wrist, forearm as far as rotary movement was concerned was completely lost. In our opinion the extreme grade of osteoporosis which was evidenced was brought about by the manipulation under an anesthetic in a hand which was suffering from this painful osteoporosis.

He came under our care and was put to bed. Plaster was inadequate because it was not possible to get rid of the edema. If the edema can not be disposed of and an unpadded plaster which absolutely fits the limb cannot be applied, the use of the rest that the plaster gives is inadequate.

Periarterial sympathectomy was done at this time, following novocaine injections of the ganglia, which resulted in some limitation or minimizing of the edema. But no appreciable improvement was noted in the patient's condition. We saw him and had him as a patient in the hospital for most of the intervening time. His condition was extremely grave and pitiful. He came into the group of cases that Dr. Bisgard mentioned in his quotation from Dr. Weir Mitchell. If one walked past the foot of his bed, he would scream with the pain. All the joints of the hand, the carpus, the elbow and the shoulder were so painful that the little bit of movement transmitted to his bed by walking across the floor was sufficient to make him scream with pain.

He demanded that we do something more, and we did a stellate ganglionectomy. There was marked osteoporosis of the humerus even though none of the x-rays showed this very well.

Patchy osteoporosis occurred in consequence of the nimiety of blood supply, which in our opinion is dependent upon the pain that the patient experiences.

I do not believe anybody knows what it is,—whether it is the acetyl-choline discharge from the nerve ends, or what it is that is responsible for the atrophy of the bones and the atrophy of the cartilages.

In any event, about three weeks ago the patient demanded that his arm be amputated. His arm was amputated at the shoulder. He is not much relieved, but we are hopeful that with the specimen we may be able to add something to our knowledge of the pathology of the disease.

\* Dr. Gurd produced pictures to illustrate his discussion.

J. DEWEY BISGARD (closing): First, I want to thank my discussers.

In the paper I included some discussion of the difficulty or impossibility of differentiating between causalgia and anxiety neuroses and malingering.

Dr. Herrmann brought out a very important point; That if we want to relieve these individuals it is necessary to give very active treatment very early. I think we are inclined to delay too long in attacking the sympathetic nervous system, either the stellate, the upper dorsal or the lumbar ganglia, or periarterial sympathectomy. As he pointed out, when patients get definite pathways established, oftentimes it is too late really to do them the service that could have been accomplished earlier.

# TRANSCONDYLAR FRACTURES OF THE HUMERUS TREATED BY DUNLOP TRACTION\*

## REPORT OF TWENTY-ONE CASES

PHILIP D. ALLEN, M.D. AND ARTHUR E. GRAMSE, M.D.

NEW YORK, NEW YORK

OUR experience with the so-called lateral traction for the treatment of transcondylar or dicondylar fractures of the humerus in children, dates from the early part of 1939

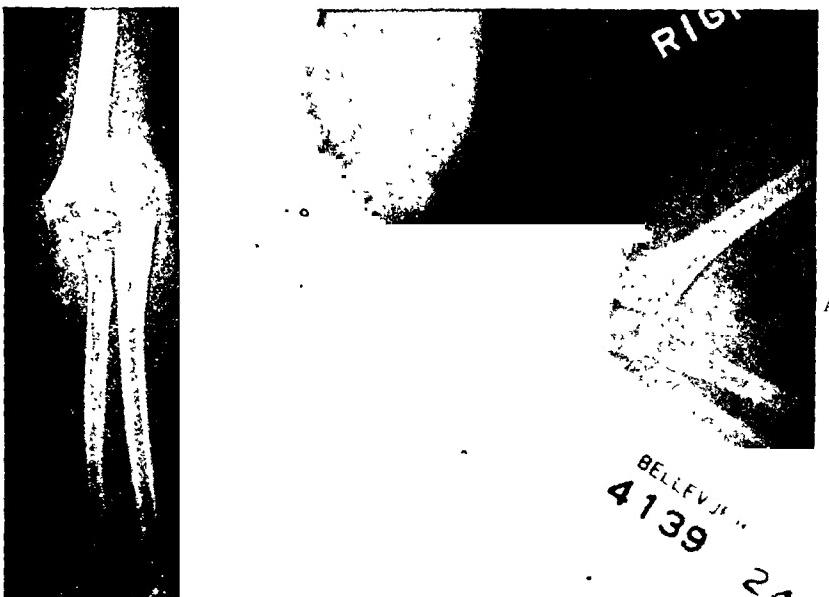


FIG. 1. Case A. L., March 31, 1939. A, anteroposterior view on admission together with anteroposterior and lateral views taken twenty-four hours later after arm was manipulated and placed in flexion. The position here seems satisfactory.

following a description of this method by John Dunlop.<sup>1</sup> John E. Sullivan now in the Armed Forces, but at that time responsible for the treatment of fractures on our Service, supervised the early cases and showed several of these children at the 1942 Annual Fracture Day Meeting of the New York and Brooklyn Regional Fracture Committee. Previous to 1939 we had used the acute flexion method as described by Jones. Our incidence of deformity

\* From the Children's Surgical Service, Bellevue Hospital, New York City.

was high, however, and we therefore welcomed a new method. To date we have employed it on a total of twenty-one patients. This type of fracture was most accurately described by Dunlop when



FIG. 1. Case A. L., April 5, 1939; b, lateral view showing posterior displacement of lower fragment while in flexion. The arm was then placed in lateral traction and two views at the right show position of the fragments nine days later. c, March 25, 1944; roentgenograms taken five years later. This child has a very slight decrease in carrying angle but with perfect function.

he described it as running through the broadened distal end of the humerus and through the olecranon fossa. He also drew attention to the typical fish-tail appearance of the distal end of the proximal fragment.

Generally speaking, we have followed most of the details outlined by Dunlop in attaching the traction immediately upon admission to the forearm up to the elbow, elevating the side of the bed and administering sedation, usually small doses of morphine. The weight



FIG. 2. Case M. G., May 10, 1941. A, roentgenogram taken on admission. Note the typical fish-tail appearance of the distal end of the upper fragment. B, May 10, 1941. Within twelve hours after application of traction note the almost perfect reduction of fragments. C, March 25, 1944. Three years after injury. This boy has a definite decrease in carrying angle with perfect function.

is then attached to the forearm with counter-traction to the arm. (Figs. 5A and B.) X-rays are then taken with the portable machine at intervals of every few hours. In a great majority of these patients



FIG. 3. Case A. N., May 31, 1941. A, the two views at the left are of a compound fracture on admission. Manipulation under anesthesia resulted in tracheal obstruction due to vomiting making bronchoscopy necessary. The view at the right represents the position after ten days in traction. B, four months and three years after fracture. In the lateral view to the left note the filling in with bone of the periosteal tube which was carried posteriorly with the distal fragment at the time of injury. Traction here did not correct the posterior displacement but did correct the rotation of the distal fragment. This boy has perfect functional and cosmetic result.

good reduction is obtained within twelve to sixteen hours. A few, however, are slow in reducing and at the present time we believe that if after twenty-four hours a satisfactory reduction has not been

attained or if at least the fragments are not showing a progressive tendency toward anatomical replacement, an anesthesia should be administered with the traction in place and manipulation done. The



FIG. 4. Case T. B., October 1, 1941. The lateral view at the left was taken on admission. The elbow was tensely swollen and there were many abrasions. The two views at the right are after nine days in traction. A five months' follow-up revealed a slight loss of extension.

amount of weight on the forearm and countertraction on the arm varies with the patient. We use from three to six pounds on the forearm and from one to three pounds as counter weight on the arm. Several of these cases present marked swelling about the elbow and in all instances the soft tissue swelling is markedly diminished with this means of treatment. The fractures in two of our patients were compounded and both of these obtained good results. In one instance the distal fragment was displaced anteriorly probably due to excessive weights in both directions. The weights were reduced, the patient was given an anesthetic and manipulated and an excellent result was obtained.

We have allowed the traction to remain in place for varying lengths of time, usually two weeks although in a few instances it remained as long as three weeks. We have been inclined to allow traction to remain until union is fairly firm, not using a plaster thereafter but have usually placed them in a sling encouraging active motion.

The narrow oblique fracture surface which is always present in these children, makes retention of reduction difficult with any other method except traction. Previous to using this method many of our

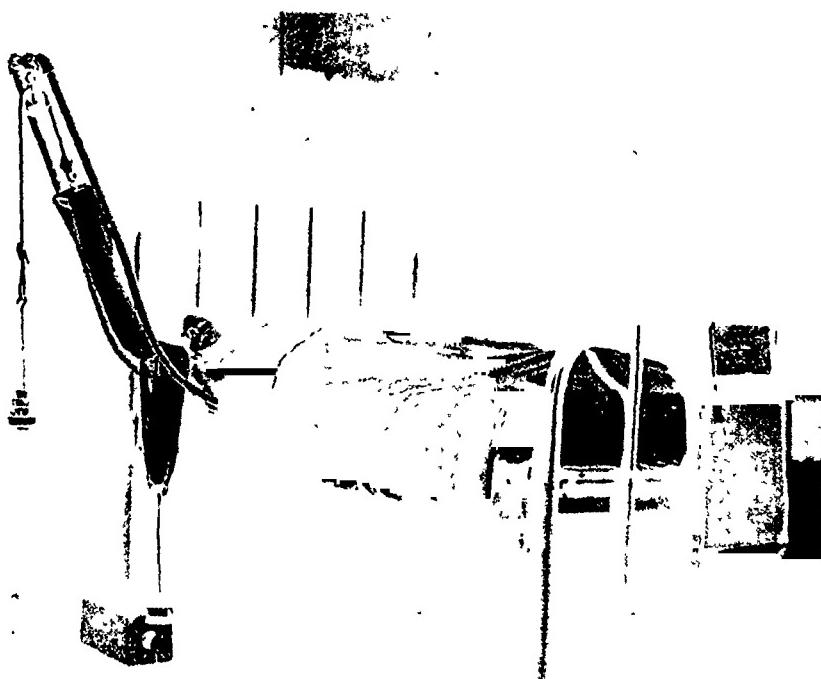


FIG. 5. A, the apparatus used for lateral traction. Note the elevation of side of bed. The amount of flexion at the elbow can be regulated by altering the position of the pulley or by the amount of weight used for countertraction.

fractures appeared to be fairly satisfactorily reduced by inspection of the x-ray films, but we believe that it was a rotation of the lower fragment in relation to the upper one that caused the bad results, chiefly alteration of the carrying angle. A moderate amount of rotation is difficult to detect accurately by x-ray. We believe that the traction method does away with rotation and even though traction may not completely correct posterior displacement of the lower fragment, we still get an excellent functional and cosmetic end result.

While the necessity for relatively long hospitalization in children treated by this method is not a serious problem in a City Hospital such as Bellevue, we believe the end results are so far superior to those attained by the known ambulatory methods that it is well worth while in all economic groups.

Of the twenty-one cases, two are recent and it is too early to evaluate end results. One of these was a girl thirteen years of age with comparatively little original displacement. She was treated on

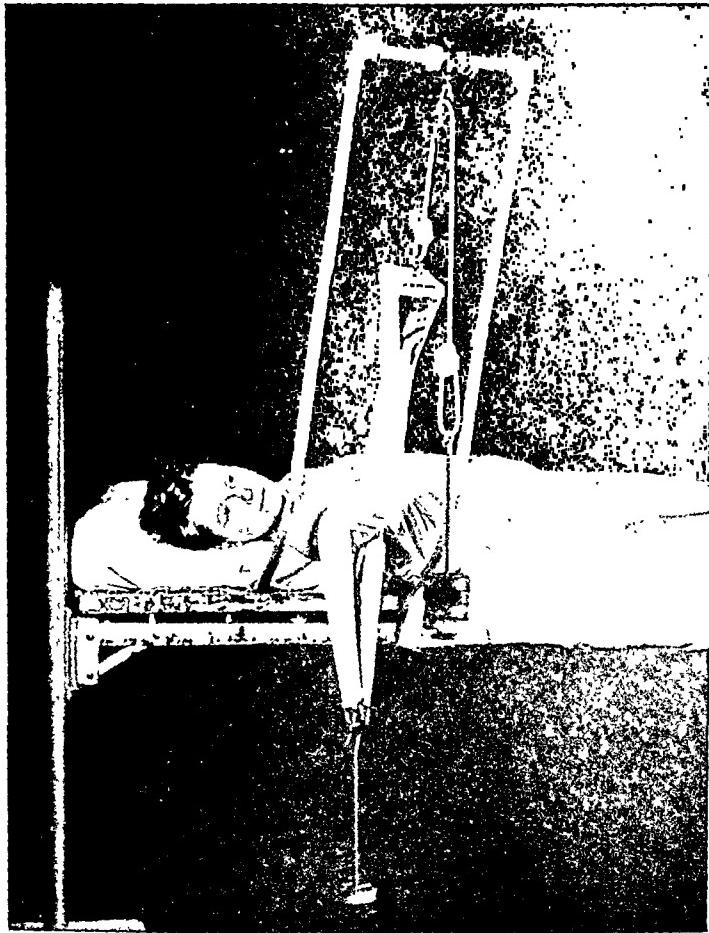


FIG. 5. B, another view of traction apparatus.

the Adult Ward. After one week in Dunlop traction, during which time the fracture was perfectly reduced, the surgeon in charge removed the traction and applied a plaster splint. A moderate amount of posterior displacement of the lower fragment occurred indicating that traction was removed too early. This patient will, however, get a good clinical result. The second patient admitted on April 8, 1944, was a boy of five who presented a wrist drop. Good apposition of fragments was obtained and there is good union. The wrist drop is rapidly improving and when seen a few days ago seemed to be on the way to an excellent result.

Fourteen of the other nineteen patients have been followed. The five not followed were comparatively simple cases who had good reductions and seemed to have excellent prognosis on discharge. One of these was a resident of Canada.



FIG. 6. Nine of the patients seen at a recent follow-up. The boy second from the left and the one at extreme right both have decreased carrying angles of the right arm. The other seven children present perfect functional and cosmetic results.

Eight patients have perfect end results. Two have decreased carrying angles, one slight and the other one quite definite, both with perfect function, however. One has a very questionable increase of carrying angle but with perfect function. One child presents a prominence of the medial humeral condyle but with perfect function. One, after a two months' follow-up had slight limitation of flexion but full extension and no other deformity. One whose follow-up ceased at five months had a very slight loss of extension. (Fig. 4.) We believe that both of these latter patients, if followed for sufficient length of time, would have perfect results.

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## DISCUSSION

JOHN DUNLOP (Pasadena, Calif.): I was pleased to be asked to discuss Doctor Allen's paper on transcondylar fractures of the humerus, because I am extremely interested in this fracture.

My attention was first called to the difficulties of its reduction in 1927, and it was first discussed by me at the Western Surgical Society at Omaha the following year. It had been my misfortune to see several cases of flexion deformity following improper reductions, and having had an experience of using traction in a badly comminuted fracture of the lower end of the humerus with remarkable reduction of the fragments and restoration of perfect function, I decided to use traction in a transcondylar case to see if a more perfect alignment might be obtained.

In the first case on which traction was used, the alignment was practically perfect and function likewise perfect. Since that experience, I have treated every transcondylar fracture in this manner with most satisfactory results. I am definitely of the opinion that should this method of treating transcondylar fractures be universally adopted, there would be considerably fewer permanently flexed elbows. No doubt, all of you have seen such deformities and many of you have one or more acquaintances with such deformities.

The diagnostic point of the fracture, when the first x-ray film is seen, is the fish-tail appearance of the lower or distal end of the proximal fragment. This appearance is caused by the fracture line crossing the olecranon fossa. When this appears, we may be quite certain that the fractured surface of the humerus is so thin or is beveled to such an extent that coaptation of the fractured surfaces is extremely difficult and even more difficult to hold. Should these surfaces be somewhat rotated one on the other, fixation is more likely possible; and the more the rotation, the more positive the fixation even to the point where the fractured surface of the distal fragment will fall into the thin surface of the olecranon fossa and by means of this produce a locking of the fragments. It is this type of alignment that destroys the olecranon fossa and permanently interferes with extension, for when the olecranon fossa is obliterated, there is no place for the olecranon to go when extension is made. So just to the extent that this olecranon fossa is filled or obliterated, so will extension be restricted.

My attention has been called to the prevention of Volkmann's ischemic paralysis by this method of treatment by some of my colleagues. I once had such a case, where all of the early symptoms had appeared, which proved this suggestion. The fracture had been reduced and plaster applied. As soon as the cast was removed and elevated traction applied, the symptoms immediately cleared up.

Because so little publicity followed my presentation in Omaha, I decided to present the subject fully as my Chairman's address at the American Medical Association's Orthopedic Section Meeting in San Francisco, 1938. Following the publication of this paper in *The Journal of Bone and Joint Surgery*, considerable interest was aroused, and it was not long before I began to hear of the use of the method far and wide. It has been a great satisfaction to me to hear from so many of my colleagues that they are adopting this method of reduction as a routine and even have added to the simple method I have advocated. As one of the men remarked "so little for so much."

I, especially, am pleased that Doctor Allen and his group at Bellevue have adopted the method; and I believe they are among the first who have been convinced as to its value. It has been a great pleasure to hear Doctor Allen and to learn of his success.\*

EDGAR L. GILCREEST (San Francisco, Calif.): The results of Dr. Allen and Dr. Gramse in the treatment of transcondylar fractures of the humerus by the Dunlop Traction was most gratifying and they are to be congratulated. I am of the opinion that a great many more transcondylar and supracondylar fractures can be treated by a closed method than are being done. I wish to call your attention to the method which I used in the treatment of a man sixty years of age who weighed 220 pounds and suffered seven fractures, three being compound and two comminuted. Slides will show how traction will often secure a reduction in the most widely displaced fragments, and that when union does occur one has a much better chance of securing a good functional result than when an open operation is performed. You will see what a splendid result this man obtained both in the reposition of the fragments as well as in the final functional result.†

WILLIAM DARRACH (New York, N. Y.): In connection with the very useful method which Dr. Allen has described by using traction on bad supracondylar fractures of the elbow, I would emphasize the point that if a satisfactory reduction is not obtained by traction alone within the first twenty-four hours, it is often wise, under a brief anesthetic, to use manipulation in addition to the traction. Many people think that they must treat a fracture by traction or by manipulation but there is really no reason why both methods should not be used on the same patient. I would also like to emphasize that with the traction method, rotary displacement of the distal fragment can be overcome by changing the direction of pull.

If the lateral films show a true lateral view of the lower fragment but the proximal fragment shows a three-quarter or an anteroposterior view, that is, the fish-tail appearance of which Dr. Dunlop spoke, one can be

\* Films were shown to show (1) the type of case, (2) the results obtained and (3) the apparatus.

† Dr. Gilcreest presented slides on this case.

sure there is a rotary displacement. With this type of fracture, with rotary displacement, I do not believe that the distal fragment can be controlled as well by the technic Dr. Dunlop brought out as by wire traction. With a wire through the upper ulna and the patient lying prone with the arm vertical, the forearm horizontal, that is, parallel with the bed, the rotation of the lower fragment can be controlled by changing the position of the forearm.

We have learned by experience that it is possible to make several different mistakes in putting a wire through the upper ulna. If it is put too near the tip of the olecranon, it passes through cartilage alone and may pull out. Secondly, as the surface of the ulna is oblique, the wire tends to skid backwards and gets only a thin shell of bone, or even periosteum alone. We have done both of these and had them pull out. This can be avoided if a small incision is made on the ulnar side of the olecranon, the soft tissues crowded forward so as to protect the ulnar nerve and then a large bore needle and used and made to engage in the bone. If the wire is put through the needle, it does not skid over the top. There is less danger of injuring the ulnar nerve if the wire is inserted from within outward rather than from without inward. The last complication we had was to insert the wire too deeply so that when the forearm was pronated it crowded the wire against the radial nerve.

In spite of these various complications we have found wire traction in these difficult supracondylars of great help, especially when there is marked swelling or any interference with the radial pulse. We have used this method in about 15 per cent of over 600 supracondylars and in no instance have we had to divide the fascia in order to relieve tension to avoid ischemic paralysis.

PHILIP D. ALLEN (closing): I believe Dr. Dunlop's remarks regarding Volkmann's ischemic paralysis were most interesting. I believe this method does have a lot to do in preventing those contractures.

In the old days when we used to put them up in flexion and when we got a lot of swelling and were afraid we were going to get a Volkmann's ischemia, we used to forget the reduction and hang them straight up in order to get rid of the edema. We have never on our service had to cut down on any of these in the anticubital fossa.

## INTERVERTEBRAL DISKS

PAUL B. MAGNUSON, M.D.

CHICAGO, ILLINOIS

**W**HENEVER I discuss this subject I feel like paraphrasing Shakespeare: I come not to bury Caesar nor to praise him. I have no quarrel with ruptured intervertebral disks when you can find them and when they are there. I have a lot of quarrel with a diagnosis of rupture of the intervertebral disk made only on the symptoms of pain in the back, referred down the leg and aggravated by sneezing and coughing.

It seems strange that in more than 10,000 dissections of spines reported by Schmorl he found only two instances of rupture of the intervertebral disk posteriorly. However, in more than 15 per cent of this series he found degeneration of the tissues around the lower spine especially, and this involved all the tissues that go to make up this portion of the spine.

If there is any condition in the body that calls for painstaking and repeated examination, not only of the back but of the patient as a whole, before diagnosis is made, it is when pain starts in the lower back, and especially when it is referred to one leg or the other.

When I started thinking about disks there were certain anatomic factors which were not entirely clear in my mind; therefore, I reviewed the anatomic charts of Dr. Callander\* and my old friend and chief, Dr. Gwilym Davis, which show certain relations between the nerve roots and the disks that are rather consistent. Incidentally, there are very few findings that are normal, in the sense that they are constant, in the lower spine. What is normal, anyway? That which is normal for one individual is not normal for another. That holds true in the lower back as consistently as it does in the contour of the face. So what is a normal back? I do not know. If a patient has symptoms in the back, we credit them to certain mechanical defects, if we can find such defects; but certainly the x-ray does not show more than 20 per cent of the conditions in the lower back that can cause pain in the back or down the leg.

Anatomic study of a cross-section of the spine at the fifth lumbar vertebra shows that the fifth lumbar nerve usually makes

\*CALLANDER, C. LATIMER: *Surgical Anatomy*, Philadelphia and London, 1933, W. B. Saunders Co.

its exit from the dura just above the level of the fourth lumbar disk. This is the rule in each vertebra above this point. The nerve passes downward and outward to enter the foramen. At the point of exit at the fifth lumbar foramen it is well below the disk. It lies immediately in front of the anterior part of the fifth lumbar inferior facet or lumbosacral articulation, just in front of the anterior part of the joint capsule. Entering the vertebra just lateral to the posterior longitudinal ligament is an internal plexus of veins. The posterior longitudinal ligament is a fibrous structure, one of the sturdiest parts of the annulus. It blends with the annulus and forms the posterior wall. The nucleus pulposus is situated just a little anterior to the posterior edge of the vertebral body. The posterior and lateral wall of the neural canal is formed by the ligamentum flavum, which is attached to each vertebral arch above and below. The ligamentum flavum is cupped out at each intervertebral foramen where the nerves exit.

In our investigations we studied ten fresh specimens of spines which had been removed very soon after death and had not been put in formalin. Dr. Larmon, who did this anatomic work, and who incidentally is the first Kemper Fellow in the Surgery of Trauma in the new group of Fellowships at Northwestern University Medical School, injected all these specimens and measured the foramina and the diameter of the nerve before and after injection. He found the average difference between the diameter of the nerve and the diameter of the foramen to be only 1 mm. He could close the foramen and cause pressure on the nerve at its exit, merely by injection of the joint with thorotrast. This does not take into consideration swelling or thickening or induration in an inflamed joint, but merely induced pressure within the joint. It is not inconceivable, therefore, that swelling, thickening or irritation around the joint or the ligamentum flavum could, and in my opinion frequently does, cause pressure on the nerve at its exit.

Willis found marked variation in the normal anatomy of the lower spine, particularly at the lumbosacral junction. These anomalies occurred in 7 per cent of 748 anatomic specimens; and Willis called attention to the fact that they could account for many of the symptoms and combinations of symptoms which occur in the lower back, especially at the fifth lumbar vertebra and lumbosacral junction. Such anomalies may be present, however, without ever causing symptoms, and I had this called to my attention rather

forcibly recently when my father, at the age of eighty-four, sustained a fracture of the fourth lumbar vertebra. The x-ray showed the body of the vertebra slipped forward 50 per cent on the first sacral, and yet he had never complained of backache.

Tropism, or an inequality of the angle of articulation of the facets on opposite sides, is seen frequently in the x-ray. Some are perpendicular on one side and horizontal on the other, with considerable variation in the angle. With such a condition existing, a patient could have all the symptoms that have been ascribed to rupture of the intervertebral disk. The same symptoms may occur without any radiologic findings as a result of gout, and in my opinion gout is much more frequent in the back than in its traditional site, the great toe. I have seen many patients recover from backache on a régime of proper diet and elimination, with no other treatment. As a matter of fact, two patients who had undergone operation for ruptured nucleus pulposus without relief of symptoms, recovered promptly when put on a proper diet.

The fifth lumbosacral joint and the fourth lumbar vertebra are called upon to bear the entire weight of the body above the pelvis. This means that the cartilage, which is not too thick on the lumbosacral joint, is pressed upon constantly when the body is in the upright position. In addition, in flexion, there is not only pressure on the cartilage but stretch on the ligaments which support the joints. With the wear and tear of life, trauma, cross-strain, infection, or a combination of any or all of these, there is wearing away of the cartilage at the weight-bearing point, exostoses built up around the joint and at the attachments of the ligaments, and degeneration of the other tissues at this point. It is little wonder that we see these degenerative changes in almost any person past the age of fifty who has performed manual labor all his life.

We are all familiar with the history of the patient who, in stooping, performing some action which he may have done thousands of times before, suddenly gets an acute stabbing pain in the back and cannot straighten up. Several weeks or months later he begins to have pain referred down the leg. To me this means there is gradual increase of thickening and pressure around the nerve at its exit from the spine. Only in two cases of exceptionally severe trauma have I seen sciatic pain occur simultaneously with the onset of pain in the back.

We have demonstrated experimentally that arthritis with exostoses can be produced by trauma alone, by weakening the joints of dogs and allowing the animals to exercise. Exostoses form around the edge of the traumatized joint and the cartilage degenerates progressively, due to often repeated slight traumas constantly administered to the poorly supported joint. The cartilage wears away at the point of greatest trauma and exostoses develop at the edge of the joint. Such pathologic changes are commonly seen in the spines of individuals who have performed heavy labor over a long period of time. When the joints become rough they do not glide normally, and the rough margins cause friction to the worn and degenerated cartilage. This interference with smooth motion in the joint can cause catching and stabbing pain with muscle spasm in the back, just as it can in joints elsewhere in the body that are more easily examined; and whether in the knee, elbow, hip, or lumbosacral joint, the degeneration of cartilage shows the same picture.

When these pathologic changes occur in an area well known to be a point of great mechanical stress, as is the lumbosacral junction, there may be marked narrowing of the intervertebral space, associated with collapse of the disk and irritation of the surrounding soft parts and bone. The annulus is pressed backward toward the canal, narrowing its anteroposterior diameter, while the foramen through which the nerve passes is diminished in size. The area of osteosclerosis is more marked at the posterior part of the vertebral body where the greatest weight is borne, that is, the point of greatest pressure.

I do not believe there can be pressure on a nerve root without referred pain. I do believe that if there is rupture of a nucleus there must be some degeneration of the tissues at that point. If there is a ruptured disk, it should be possible to trace the symptoms back to pressure on a nerve root. However, in any case with a typical history of pain in the lower back with subsequent pain referred down the leg, it would appear more logical to institute conservative treatment first; rest, with traction, moderate immobilization and support, then gradually increased exercise, just as we treat other injured joints. If such treatment is not successful, exploration for a ruptured disk is permissible. Whether or not a disk is found, I believe fusion of the spine should be done at the time of operation to insure permanent relief.

I believe Dr. Magnuson is right when he states that the disorder in many of these cases lies in the facets. In those cases which we have re-explored we have not found a recurrent protrusion of the disc, but we have found the facets to be abnormally placed. In some cases the joint surfaces have been widely separated, in others there has been narrowing of the joint space with degeneration of the articular cartilage. All such cases show a good deal of thickening of the capsule. Whether such thickening is sufficient to cause root pain, I do not know. I am inclined to believe with Dr. Magnuson that it does.

One thing I cannot quite understand in Dr. Magnuson's paper is why there should be a delay in the onset of pain in these arthritic joints. The acute pain in an arthritic knee comes when the joint is acutely swollen. If an arthritic interfacet joint should become inflamed, I should think the referred pain would be immediate and not delayed for some months. This is a minor point perhaps.

In those cases in which we have not had an opportunity to re-explore and fuse we have attempted manipulation and radiation. We have used the Jostes method under an anesthetic with some success. Radiation has been of some value but our success has not measured up to the claims of some roentgenologists.

I agree with Dr. Magnuson that we should not be too ready to remove the disc in cases with referred leg pain. The large percentage of such cases do not have ruptured discs. The disorder may be due to chronic strain on abnormally placed facets. When our cases are studied from this point of view, we are more likely to be successful in our handling of the difficult problem.

EDGAR L. GILCREEST (San Francisco, Calif.): It is a trite expression that "A rose by any other name smells just as sweet." Dr. Magnuson has given us a very comprehensive discussion of backache under the title of "intervertebral discs," and I think that you will agree that he showed that most backache is not due to protrusion of discs.

In his discussion of the subject he mentioned some basic things, but I think he overlooked one, and that is that many of these patients with backache can be cured by manipulation. I think a word ought to be said about that, because in a discussion of backache, such as we have had in the last few moments, not a word has been said about manipulation.

We are letting the cults take that over from us, and there are thousands of people today being treated for backache all over this country by pretty competent osteopaths, who also treat, I think, a great many of the doctors in California who sprain their back playing golf.

They go to osteopaths because they do not think any doctor of medicine can treat backache except by operating or strapping their back or prescribing a liniment. They also go to the chiropractors, who do not do the work as well as the osteopaths.

When we see these cultists actually relieving hundreds and thousands of people with backache, we should not any longer ignore the procedure of manipulation simply because these cultists often use it inadvisedly.

I believe there is not one doctor in ten who knows really very much about manipulating the back. I know when I went to medical school I never heard the subject mentioned. I have talked to doctors all over the United States, and I believe I am correct in saying that few have ever considered the subject seriously.

I have found there are two or three manipulations that often may relieve a person with backache who has been for days or weeks listing to one side, and unable to lean over and button his shoes. The procedure which I use briefly is as follows: The patient lies on his back on a narrow, firm table. He is told to relax. The manipulator, standing at the end of the table, grasps in each hand the patient's heel and ankle and slowly and gently rocks, with a rotatory motion, the lower limbs on the pelvis, reassuring the patient and thereby obtaining the relaxation desired. One lower extremity is then allowed to hang over the side of the table and the other is flexed on the pelvis in order to hold the pelvis steady. Pressure is then gently, but firmly, exerted on the limb hanging over the edge of the table for a few minutes, while counterpressure is exerted on the flexed limb. The position of the limbs is then reversed and the maneuver repeated.

The patient is then put on his side with the lower extremity, nearest to the table, extended fully and the other one flexed at the knee. Pressure is exerted downward on the flexed knee while counterpressure is put on the shoulder of the same side so as to obtain a rotation of the spine, clockwise of the pelvis, and counterclockwise of the shoulder. This same maneuver is repeated with the patient on the other side, changing the position of the legs. During this maneuver, which must also be carried out gently but firmly, a definite snap is frequently felt by the patient and may even be audible to bystanders. When this occurs the pain usually ceases instantly, the patient is completely relieved or may feel only a soreness in the low back. The movements of the back immediately become freer, and the patient delights in trying them out, and as soon as he gets off the table will, almost invariably, bend forward, a movement which he could not make previously, to see if he can reach to his shoes.

Another simple and quick manipulation which may work well in some patients who are not too large or heavy is as follows: Stand the patient back-to-back with yourself, and then put your arms under his axillae and lean forward, lifting him up on your back, hyperextending his lumbo-sacral region, and then suddenly give a hump or jump which will often instantly relieve him.

PAUL B. MAGNUSON (closing): Thank you very much for this interesting discussion. Dr. Aitken thought there was some question as to whether the pressure was due to the vertebrae. Of course we do not know the angle

of the joints, either perpendicularly or laterally, and it is hard to say how much pressure is caused by the joint and how much of the swelling and thickening occurs after induration occurs. In other joints, however, my experience has been that pain occurs as soon as the joint is locked, and swelling follows.

There is nothing new about manipulation. Hippocrates used it and possibly he was not the originator. When I started practice at the Stockyards these workmen were sent in with an acute pain in the back, who had performed the same actions in the same kind of work for twenty years and suddenly had this acute pain. Quite frequently I relieved them by manipulation. After hearing about a complete transverse lesion occurring as a result of manipulation, I got cold feet and decided that something a little less strenuous might work as well. I found that putting the patient to bed with traction applied, giving rest to the joint, gave just as good a result, and I do not think rough manipulation is justified. These tissues, in my opinion, are degenerated, and should be treated with consideration.

We do not know too much about this, anyway. We are working on a theory. These patients do not die, and we do not have an opportunity to do an autopsy and find out what the circumstances were. Until we have a complete history on a case and have a competent examination made prior to autopsy, I do not think we can come to a definite conclusion that any treatment works 100 per cent.

## SURGICAL APPROACHES FOR SURGERY OF THE EXTREMITIES

WILLIAM DARRACH, M.D.  
NEW YORK, NEW YORK

**T**HE surgical approaches to be described have been used with satisfaction for a number of years by the author and his staff. No originality is claimed for any of them and most of them will be recognized as old standard procedures.

The criteria for a good surgical approach are: (1) It should provide comfortable access to the structures sought for; (2) it should do as little damage as possible; (3) it should pass between rather than through muscles; (4) it should pass these muscles on the side opposite their blood and nerve supply; (5) it should permit actual visualization of important structures or pass a safe distance from them; (6) it should be possible at the close of the operation to restore the disturbed structures to their normal position and have them regain their normal function as quickly as possible.

### SHOULDER

The shoulder joint and upper humeral region may be approached from in front, from above, or from behind. The important anatomical barrier is the deltoid muscle and its nerve supply, the axillary or circumflex nerve. The latter is given off from the posterior cord and passes backward through the quadrilateral space behind the surgical neck, entering the deltoid from behind. (Fig. 1.) Any splitting of the deltoid fibers must be limited to the upper 4 cm. as any injury to the nerve fibers will result in permanent atrophy of the portion of the muscle anterior to the incision.

*Anterior Approach.* If one is interested only in the subdeltoid bursa and the tendons inserting into the tuberosities, this region may be exposed through a vertical incision 5 cm. in length running downward from a point just anterior to the anterolateral margin of the acromion. (Fig. 2.) The separation of the deltoid fibers should be made bluntly from above downward, crowding the nerve fibers downward rather than cutting them. By retracting the muscle and rotating the humerus, most of the tuberosity region may be visualized.

When a freer exposure is necessary, the approach is made between the anterior margin of the deltoid and the adjacent pectoralis major. The cephalic vein marks this interval. (Fig. 3.) It should be

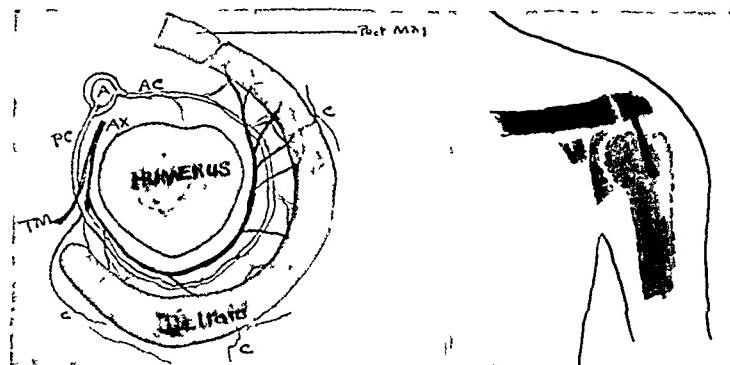


FIG. 1. Relation of circumflex vessels and nerves to humerus. A, axillary artery; AC, anterior circumflex artery; PC, posterior circumflex artery; AX, axillary (circumflex) nerve; TM, branch to teres major; c, cutaneous branches of axillary nerve.

FIG. 2. Exploratory incision. This can later be extended to a transacromial.

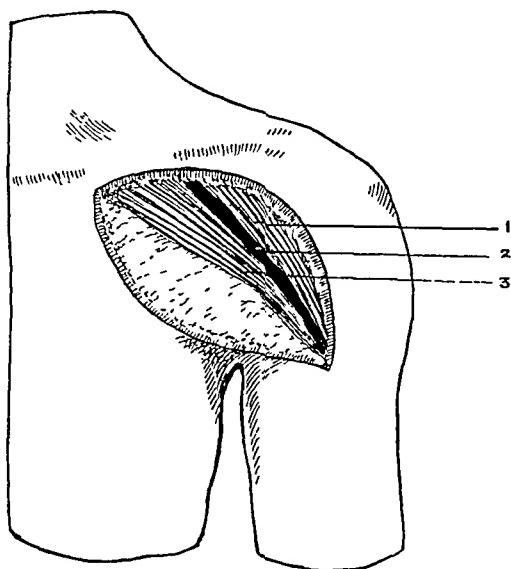


FIG. 3. Anterior approach to shoulder. 1, deltoid; 2, cephalic vein; 3, pectoralis major.

remembered that with the arm abducted to 90 degrees the axillary vessels and brachial plexus pass across the shoulder joint and humeral head. With the arm at the side or with not more than 30

degrees of abduction, these structures lie well below and to the inner side and well out of the way. (Fig. 4.) The skin incision starts 2 cm. to the inner side of the tip of the coracoid, passes outward

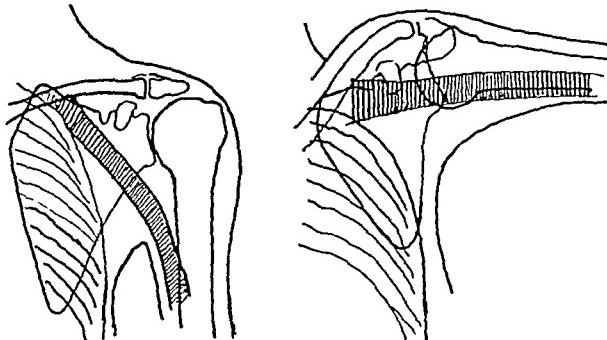


FIG. 4. Relation of axillary vessels and plexus to humeral head in adduction and relation of axillary vessels and plexus to humeral head in abduction.

parallel to the clavicle and then curves downward opposite the acromioclavicular joint for about 7 cm. (Fig. 5.) The flap is dissected up until the cephalic vein is exposed. By retracting the deltoid upward and outward the outer margin of coracobrachialis and short head of the biceps are seen passing vertically downward. Division of the fascia extending outward from these will expose the subscapularis inserting into the lesser tuberosity. (Fig. 6.)

If more room is needed, the anterior deltoid fibers must be divided close to their clavicular attachment and the flap turned outward and downward. (Fig. 7.) The anterior circumflex vessels, passing to the front of the surgical neck should be avoided. More of the axillary space and its contents can be exposed by dividing the coracoid between the attachments of the pectoralis minor and the coracobrachialis and biceps. The coracoid tip and these two latter muscles are then turned downward and inward. Care must be taken not to injure the musculocutaneous nerve and its branch to the coracobrachialis. (Fig. 8.) In closing the wound the base of the coracoid is drilled and the tip held in place by a silk or wire suture; the divided deltoid fibers are reattached to the clavicle and the skin closed.

*Posterior Approach.* The upper humerus and shoulder can be exposed from behind along the posterior margin of the deltoid. The main structure to be avoided is the axillary or circumflex nerve. This will be found passing from the lower axilla backward between

FIG. 5.

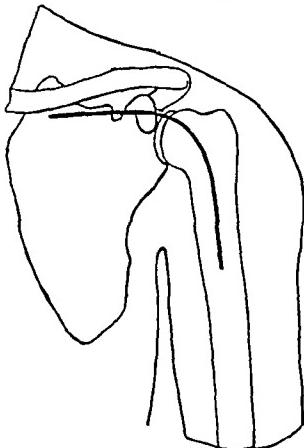


FIG. 6.

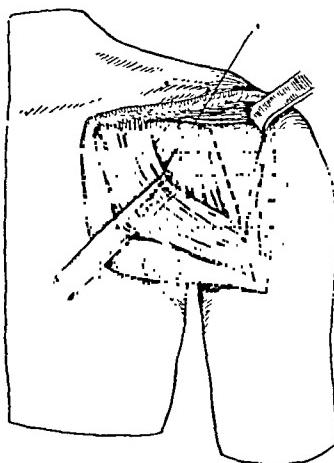


FIG. 7.

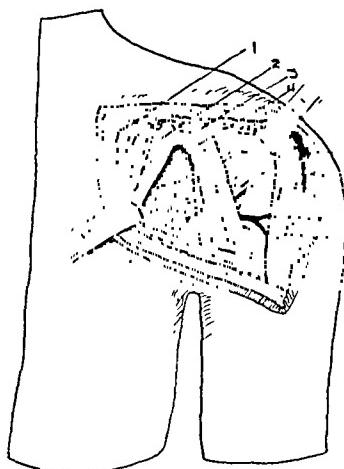


FIG. 8.

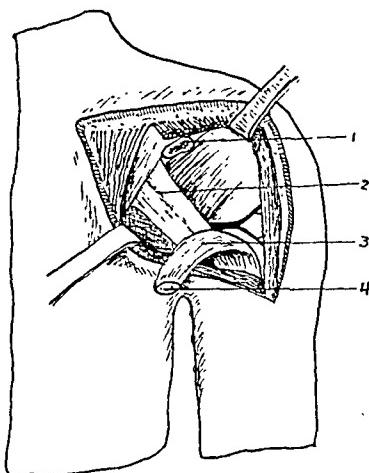


FIG. 5. Anterior approach to shoulder; line of incision.

FIG. 6. Anterior approach to shoulder, deltoid and pectoralis major separated. 1, coracoid; 2, pectoralis minor; 3, coracobrachialis and biceps; 4, deltoid (retracted); 5, line of fascial incision; 6, pectoralis major.

FIG. 7. Anterior shoulder approach; division of anterior fibers of deltoid. 1, pectoralis major; 2, pectoralis minor; 3, cut surface of deltoid; 4, coracoid; 5, subscapularis; 6, capsule over humeral head; 7, coracobrachialis and biceps; 8, anterior circumflex vessels; 9, deltoid.

FIG. 8. Anterior shoulder approach, coracoid divided and coracobrachialis and biceps reflected. 1, cut surface of coracoid; 2, axillary vessels and plexus; 3, coracobrachialis and biceps reflected; 4, tip of coracoid.

the humeral neck and the long head of the triceps, the teres major and minor. The incision follows the deltoid margin and the smaller cutaneous branches of the axillary nerve, encountered as they pierce

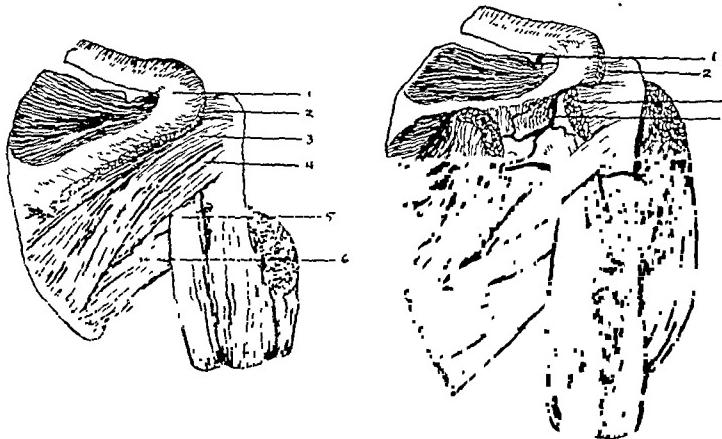


FIG. 9.

FIG. 9. Deep layer of shoulder muscles from behind, deltoid divided near its origin and removed. 1, acromion; 2, supraspinatus; 3, infraspinatus; 4, teres minor; 5, long head of triceps; 6, teres major.

FIG. 10.

FIG. 10. Posterior aspect of shoulder showing relation of vessels and nerves. 1, transverse scapular (suprascapular) artery; 2, supraspinatus; 3, infraspinatus (divided); 4, transverse scapular (suprascapular) infraspinal branch; 5, axillary nerve (circumflex); 6, circumflex scapular (dorsalis scapular) artery; 7, posterior circumflex humeri artery; 8, teres minor; 9, radial nerve; 10, teres major; 11, deltoid; 12, triceps, long head; 13, latissimus dorsi.

the deep fascia, will act as a guide to the main nerve trunk. When located this can be retracted upward and inward. This route provides a safe exposure of the upper humerus and inferior part of the joint. This incision usually leaves a very broad scar. (Figs. 9, 10 and 11.)

*Transacromial Approach.* This modification of the so-called "saber cut" approach gives a free exposure of the upper aspect of the shoulder joint with the attachment of the intrinsic muscles to the tuberosities, without endangering any important nerves or blood vessels. It is useful in cuff tears, complicated fractures of the upper humerus with or without dislocation, and gives room enough to carry out the Nicola procedure. The outer portion of acromion and attached deltoid are reflected outward and downward, exposing the intrinsic shoulder muscles and the upper humerus. (Figs. 12 and 13.) The skin incision (Fig. 14) crosses the acromion in the sagittal plane a short distance mesial to its outer border, passing downward 2 cm. behind and 3 cm. in front of the bone. The acromion is divided

obliquely from the posterolateral angle to a point 2 cm. mesial to its anterolateral corner. Splitting the deltoid fibers in front and behind allows the bone fragment and attached muscle to be retracted

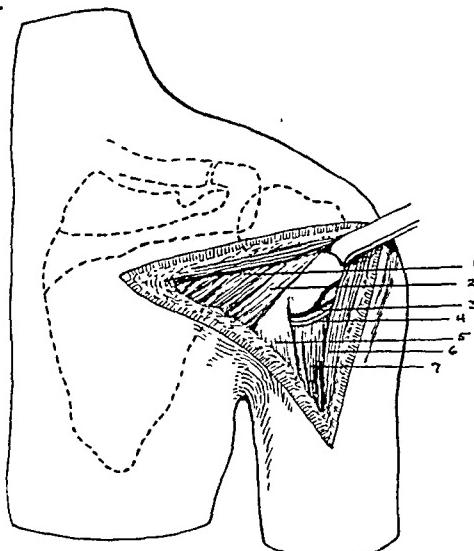


FIG. 11. Posterior shoulder approach. Incision along posterior margin of the deltoid, the latter (No. 6) retracted upward and outward showing underlying structures. 1, infraspinatus; 2, teres minor; 3, posterior circumflex artery; 4, axillary (circumflex) nerve; 5, long head of triceps; 7, outer head of triceps.

outward and downward. (Fig. 15.) In closure, if the bone fragment is excised and the deltoid reattached to the acromion, the convalescent period will be shortened, and active movements may be started earlier than if bony union were required.

#### ARM

In the upper two-thirds of the arm, all the important vessels and nerves lie in the inner part of the anterior compartment, with the exception of the radial nerve. The latter, with its accompanying blood vessels, passes obliquely downward and outward, lying close to the posterior aspect of humerus between the inner and outer heads of the triceps. The safest route to the humerus passes along the posterior margin of deltoid and either just in front of the lateral intermuscular septum or through the outer fibers of the brachialis muscle. (Figs. 16 and 17.) At the junction of the middle and lower

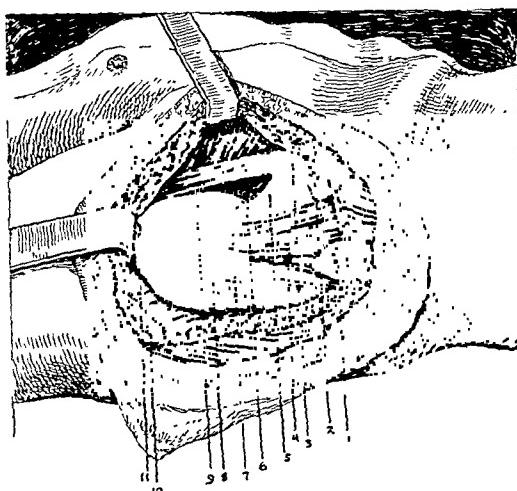


FIG. 12. Dissection of shoulder from above. The outer portion of clavicle, spine of scapula and acromion have been removed, the tip of the latter and deltoid reflected outward and downward, exposing the roof of the shoulder joint; mid-rotation. 1, stump of spine of scapula; 2, stump of clavicle; 3, coracoid process; 4, transverse scapular artery; 5, coracohumeral ligament; 6, coracobrachialis and biceps; 7, supraspinatus; 8, infraspinatus; 9, subscapularis; 10, tip of acromion; 11, bicipital groove.

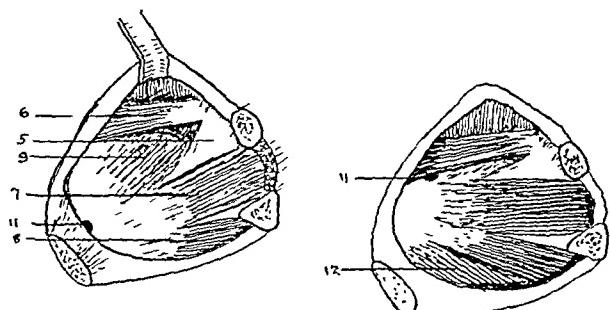


FIG. 13. Relation of cuff muscles in outward and inward rotation of shoulder. 5, coracohumeral ligament; 6, coracobrachialis and biceps; 7, supraspinatus; 8, infraspinatus; 9, subscapularis; 11, bicipital groove; 12, teres minor.

thirds the radial nerve pierces the lateral intermuscular septum to lie deep between the brachialis and brachioradialis muscles. The approach in the lower third of the arm, therefore, should be along

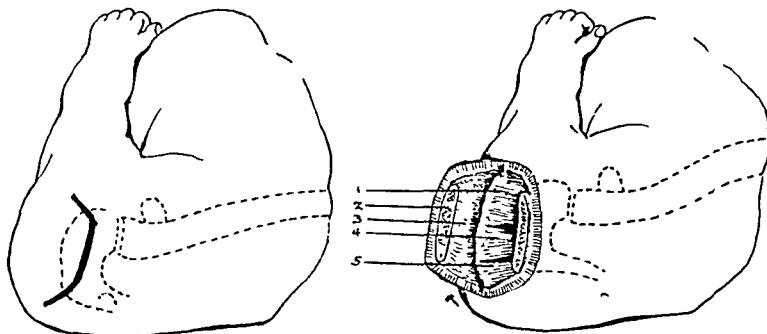


FIG. 14.

FIG. 15.

FIG. 14. Transacromial approach to shoulder; skin incision.

FIG. 15. Transacromial shoulder approach. 1, subscapularis; 2, acromion divided and turned outward; 3, deep surface of deltoid; 4, supraspinatus; 5, infraspinatus.

the anterior margin of the latter muscle. In a fracture of the humeral shaft, this route makes it possible to explore the relation of the radial nerve to the ends of the bone. (Fig. 18.)

#### ELBOW

The elbow region may be explored safely from any direction except the anteromesial where the brachial vessels and the median nerve lie. Vertical and oblique incisions across the fold of the elbow tend to give wide scars which often contract and may interfere with extension. Transverse incisions heal with narrow scars and can be used when a limited exposure is necessary or they can be combined with vertical extensions.

*Anterolateral Approach.* This route passes between the brachioradialis and the biceps and through the outer fibers of the brachialis. The following structures are encountered: One of the superficial veins, usually the median cephalic (Fig. 19) requiring ligation; the lateral antebrachial cutaneous branch of the musculocutaneous which emerges from the outer margin of the biceps about 5 cm. above the joint line and pierces the deep fascia and runs downward and outward to the forearm (Fig. 20); the anterior radial recurrent vessels will be encountered in the lower part of the wound as they emerge from beneath the outer margin of the pronator teres and require ligation; the radial nerve lying deep in the space between

the brachioradialis and brachialis and passing downward on the latter muscle. As all the branches of the radial nerve pass laterally in this region, if the nerve is identified and the branchialis fibers

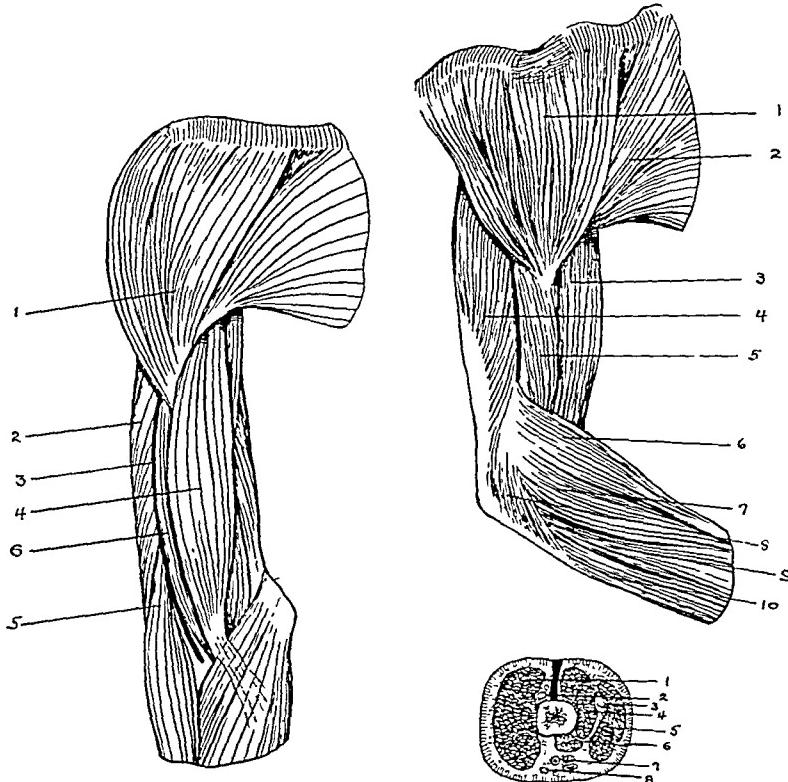


FIG. 16.

FIG. 16. Anterior aspect of arm. 1, deltoid; 2, triceps; 3, line of incision; 4, biceps; 5, brachioradialis; 6 brachialis.

FIG. 17. Lateral aspect of arm; incision line in black, 1, deltoid; 2, pectoralis major; 3, biceps; 4, triceps; 5, brachialis; 6, brachioradialis; 7, extensor carpi radialis longus; 8, aconeus; 9, extensor carpi radialis brevior; 10, extensor communis digitorum. Cross section of arm, middle third. 1, triceps; 2, radial nerve; 3, musculocutaneous nerve; 4, brachialis; 5, biceps; 6, coracobrachialis; 7, brachial artery; 8, ulnar nerve.

split to the inner side of the nerve, the latter will escape injury. The skin incision should be "step-cut," the upper vertical portion along the margin of the brachioradialis, the horizontal opposite the joint line and again vertically downward. (Fig. 21.) After ligating the vein and retracting the musculocutaneous nerve (Fig. 22) the inner margin of the brachioradialis is freed and the muscle retracted outward until the radial nerve is identified. The latter is followed downward and the anterior radial recurrent vessels divided between

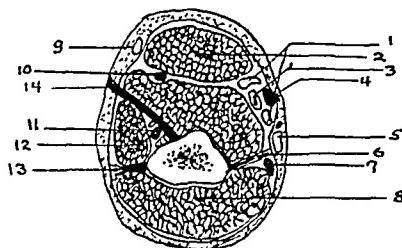


FIG. 18. Cross section of lower third of humerus. 1, brachial veins; 2, biceps; 3, brachial artery; 4, median nerve; 5, basilic vein; 6, medial intermuscular septum; 7, ulnar nerve; 8, triceps; 9, cephalic vein; 10, musculocutaneous nerve; 11, radial nerve; 12, brachioradialis; 13, lateral intermuscular septum; 14, line of incision.

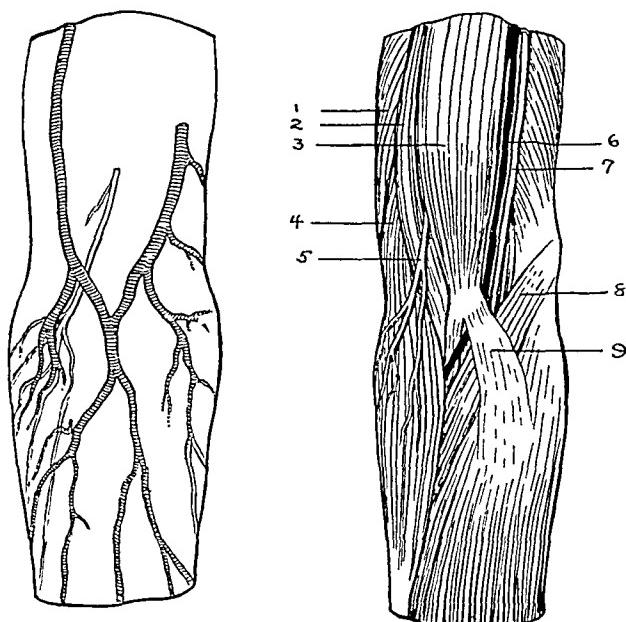


FIG. 19.

FIG. 19. Elbow, anterior aspect; superficial veins and musculocutaneous nerve.

FIG. 20. Elbow; anterior aspect; 1, triceps; 2, brachialis; 3, biceps; 4, brachioradialis; 5, musculocutaneous nerve; 6, brachial artery; 7, median nerve; 8, pronator teres; 9, lacertus fibrosus.

ligatures. (Fig. 23.) The incision is then deepened through the outer fibers of the brachialis and the joint capsule. (Fig. 24.) In closing, the structures tend to fall into place and only a few sutures are

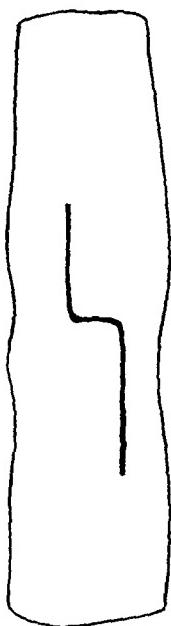


FIG. 21.

FIG. 21. Elbow; anterolateral approach; skin incision.

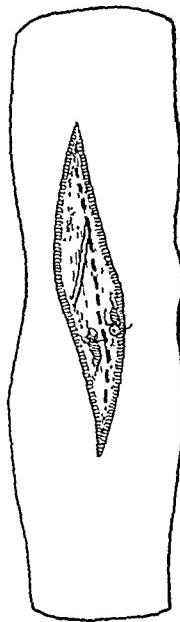


FIG. 22.

FIG. 22. Elbow; anterolateral approach showing musculo-cutaneous nerve and divided superficial vein; dotted line, fascial incision.

required for the capsule and deep fascia. This approach is useful in exploring the front of the elbow joint, removing fragments of radial head which lie in front of the capsule, repairing anterior dislocations of radius, or capitellar or trochlear fractures.

*Lateral Approach.* The interval between the capitellum and the radial head provides the shortest route to the elbow joint. This is where joint swelling first becomes evident and where aspiration should be carried out. The only intervening structures besides skin, fascia and capsule are the aponeurotic fibers of the extensor muscles attaching to the lateral condyle and the upper fibers of the supinator muscle. (Fig. 25.) One must avoid the dorsal interosseous branch of the radial nerve as it passes obliquely backward lateral to the neck of the radius between the two layers of the supinator. (Fig. 26.) The incision passes from the lateral epicondyle downward in the axis of the forearm. (Fig. 27.) Through this route the radial

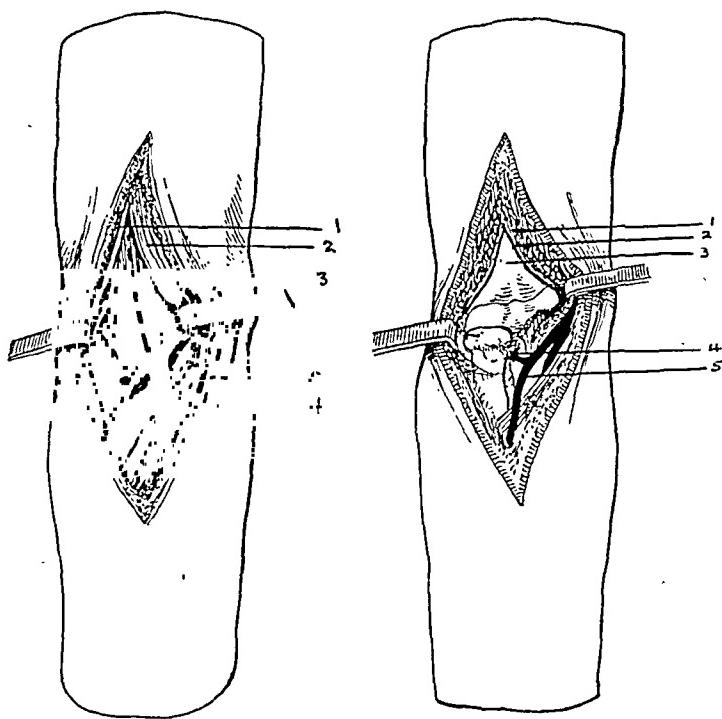


FIG. 23.

FIG. 24.

FIG. 23. Anterolateral approach. 1, radial nerve; 2, biceps; 3, brachialis; 4, pronator teres; 5, radial recurrent artery.

FIG. 24. Anterolateral approach. 1, brachialis (divided); 2, capsule (divided); 3, humerus; 4, anterior radial recurrent artery (divided); 5, radial artery.

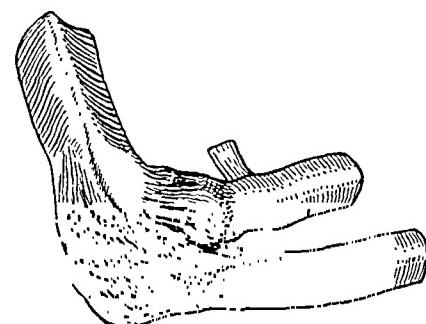


FIG. 25. Lateral aspect of elbow; bones and capsule.

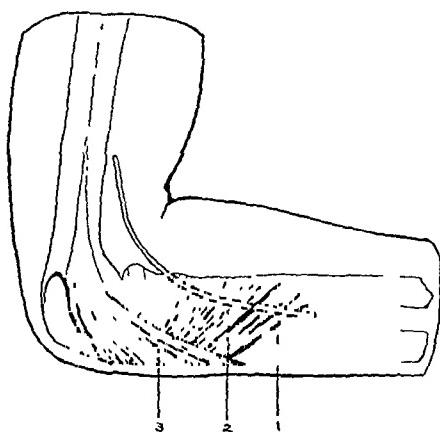


FIG. 26.

FIG. 26. Lateral aspect of elbow. 1, posterior interosseous nerve emerging from between two layers of supinator; 2, supinator; 3, acromius.

FIG. 27. Lateral approach to elbow. 1, capitellum; 2, radial head; 3, orbicular ligament; 4, supinator; 5, ulna; 6, radius.

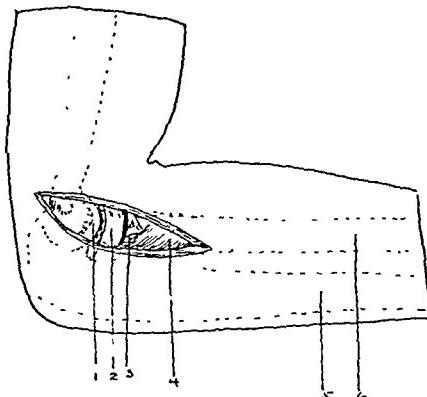


FIG. 27.

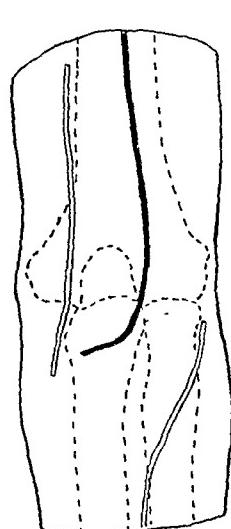


FIG. 28.

FIG. 28. Posterior approach to elbow showing line of incision, ulnar and posterior interosseous nerves.

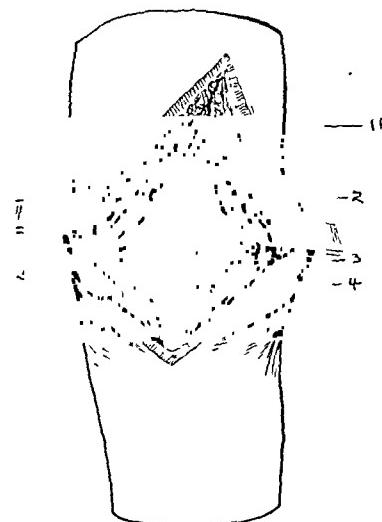


FIG. 29.

FIG. 29. Posterior elbow approach. 1, triceps, split and retracted; 2, capsule; 3, olecranon fossa; 4, cut surface of olecranon; 5, tip of olecranon retracted inward.

head can be removed. To replace and fix a fracture of the lateral condyle, the incision should extend a little higher.

*Posterior Route.* The attachment of the triceps to the olecranon

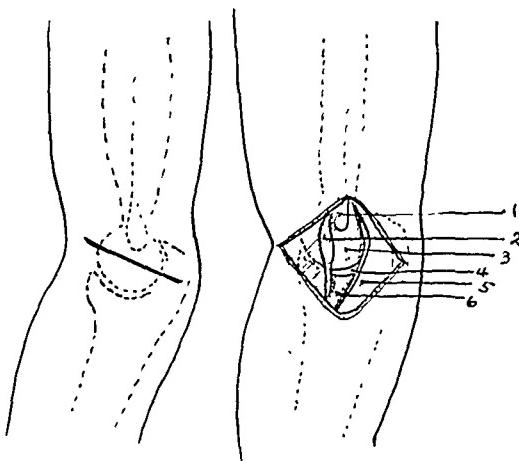


FIG. 30.

FIG. 30. Mesial approach to elbow; skin incision.

FIG. 31.

FIG. 31. Mesial approach to elbow; horizontal skin incision, retracted up and down; vertical incision through soft parts. 1, medial epicondyle; 2, pronator and flexor attachments retracted forward; 3, inner surface of trochlea; 4, joint space; 5, dorsal structures covering ulnar nerve; 6, inner surface of ulna.

makes this approach difficult unless the latter is divided and turned to one side. In order to avoid injury to the ulnar nerve as it lies in the groove behind the medial epicondyle, it is better to make the vertical part of the incision along the lateral margin of the olecranon, swinging horizontally inward about 3 cm. below its tip. (Fig. 28.) The bone should be divided opposite the bottom of the greater sigmoid notch. If it is divided from within outward, there is less danger of injuring the ulnar nerve. By reflecting the olecranon and attached triceps inward, a free exposure of the lower humerus is obtained. (Fig. 29.)

*Mesial Approach.* For fractures of the medial epicondyle or medial condyle, the bone can be exposed by separating the periosteum and origin of the medial collateral ligament, the pronator teres and flexor group from the lower portion of the medial supracondylar ridge and epicondyle in a vertical plane. If the skin is divided in the same line, the scar is apt to widen; so it is better

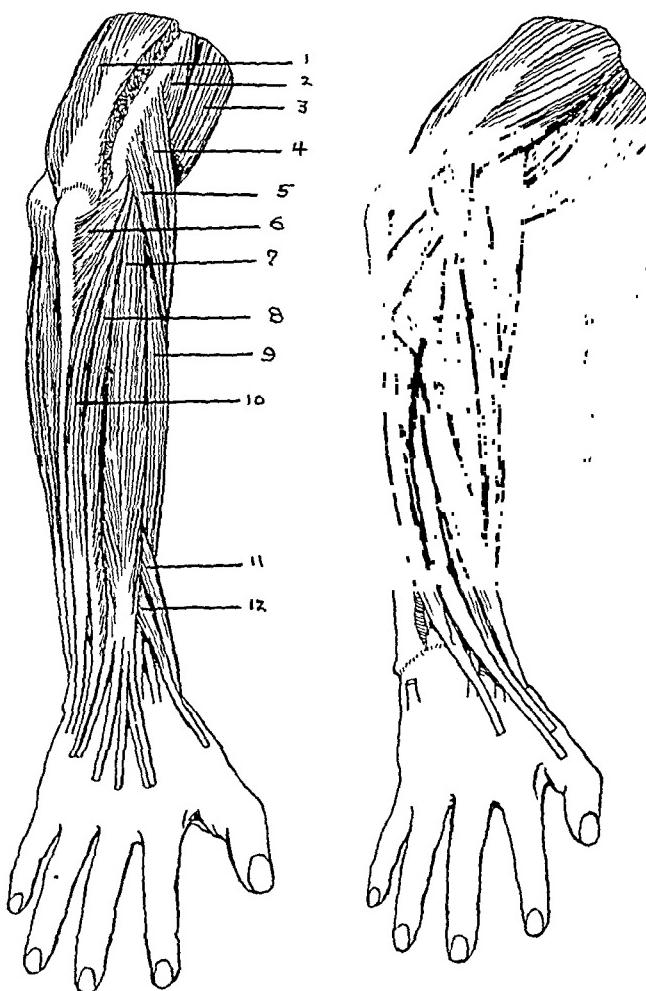


FIG. 32.

FIG. 32. Dorsal aspect of forearm, superficial layer. 1, triceps; 2, brachialis; 3, biceps; 4, brachioradialis; 5, extensor carpi radialis longior; 6, acroneus; 7, extensor communis digitorum; 8, extensor minimi digiti; 9, extensor carpi radialis brevior; 10, extensor carpi ulnaris; 11, abductor longus pollicis; 12, extensor brevis pollicis.

FIG. 33.

FIG. 33. Dorsal aspect of forearm, deep layer. 1, extensor communis (divided); 2, brachioradialis; 3, acroneus; 4, extensor carpi radialis longior; 5, extensor carpi radialis brevior; 6, supinator; 7, abductor longus pollicis; 8, extensor brevis pollicis; 9, posterior interosseous nerve.

to make a horizontal skin incision with dissection of upper and lower flaps. (Figs. 30 and 31.)

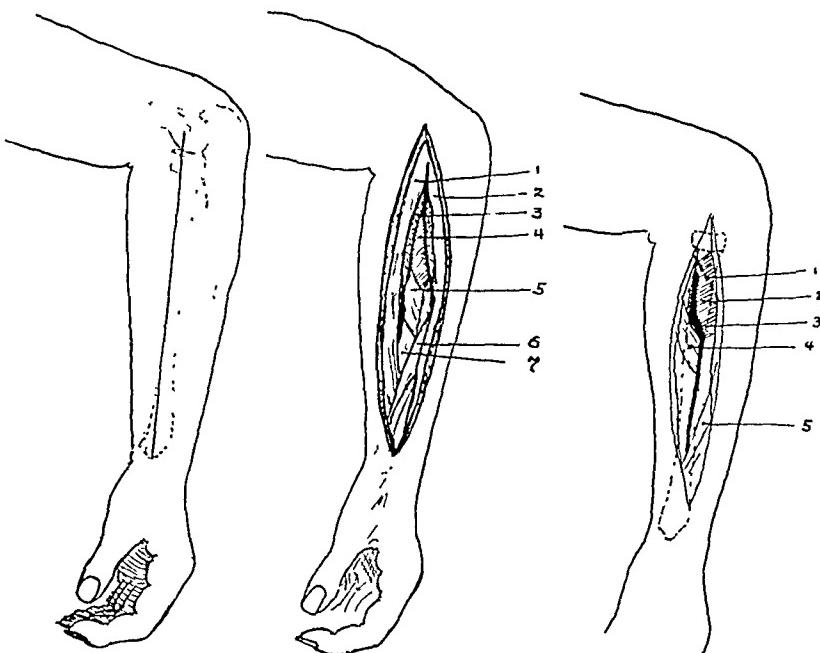


FIG. 34.

FIG. 35.

FIG. 36.

FIG. 34. Posterolateral approach to radius, route of incision.

FIG. 35. Posterolateral approach to radius. 1, extensor carpi radialis brevis; 2, extensor digitorum communis; 3, extensor carpi radialis brevis stripped from intermuscular septum between it and extensor digitorum communis; 4, supinator; 5, tendon of pronator teres; 6, abductor pollicis longus; 7, radial shaft.

FIG. 36. Posterolateral approach to radius. 1, crossing of posterior interosseous nerve; 2, supinator; 3, line of periosteal incision; 4, pronator teres; 5, abductor pollicis longus.

#### FOREARM

*Ulna.* As the dorsal aspect of the ulna is subcutaneous throughout its whole extent, its approach is simple.

*Radius, Upper Shaft.* The upper two-thirds of the radial shaft is well covered by muscle. (Figs. 32 and 33.) Any anterior approach endangers the blood and nerve supply of the flexor group. Posteriorly, the dorsal interosseous nerve must be avoided. If the interval between the extensor communis digitorum and the extensor carpi radialis brevis is used, no large vessels are encountered; but in the lower part of the incision, the superficial branch of the radial must be avoided as it passes backward from beneath the tendon of

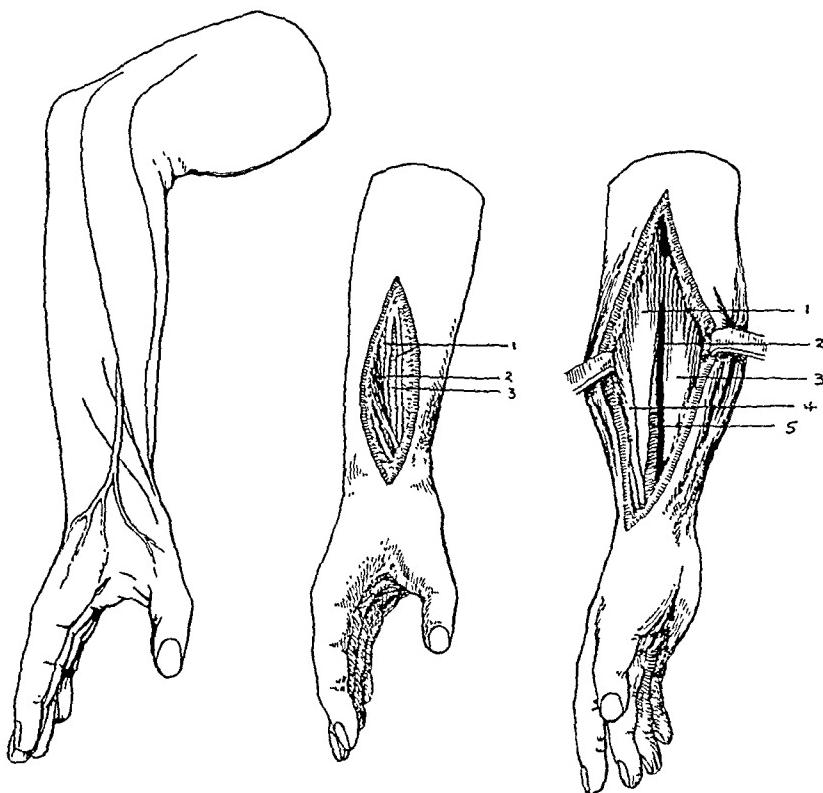


FIG. 37.

FIG. 38.

FIG. 39.

FIG. 37. Lateral approach to lower radius showing relation of superficial radial nerve to tendons of brachioradialis and abductor pollicis longus.

FIG. 38. Lateral approach to lower radius. 1, split tendon of brachioradialis; 2, abductor pollicis longus; 3, radial shaft.

FIG. 39. Lateral approach to lower radius showing relation of radial vessels. 1, brachioradialis; 2, radial vessels; 3, flexor carpi radialis; 4, abductor pollicis longus; 5, pronator quadratus.

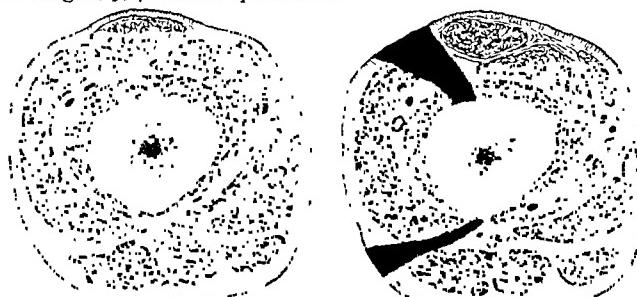


FIG. 40.

FIG. 40. Cross section of mid-thigh.

FIG. 41. Cross section of mid-thigh showing anterolateral and posterolateral routes to femur.

the brachioradialis. With the elbow at right angles and the forearm in mid-pronation an incision made along a line from the lateral epicondyle to the radial styloid will expose the interval between

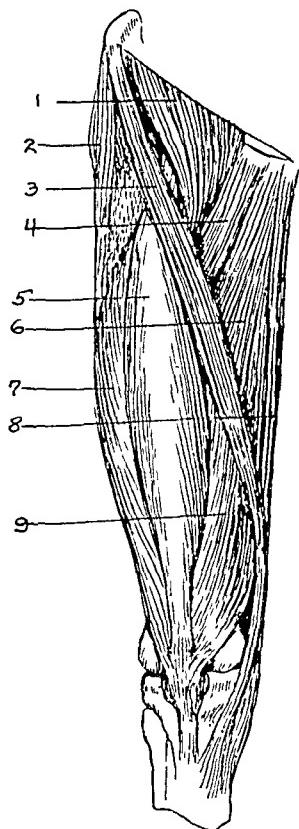


FIG. 42.

FIG. 42. Anterior femoral region. 1, psoas iliacus; 2, tensor fasciae femoris; 3, sartorius; 4, pectineus; 5, rectus femoris; 6, adductor longus; 7, vastus lateralis; 8, gracilis; 9, vastus medialis.

FIG. 43. Anterolateral approach to femur (rectus, sartorius, tensor and glutei removed). 1, anterior-superior spine of ilium; 2, cut end of sartorius; 3, cut end of rectus; 4, transverse and ascending branches of lateral circumflex artery; 5, anterior femoral nerves; 6, common femoral artery and vein; 7, profunda femoral artery; 8, pectineus; 9, descending branches of lateral circumflex artery; 10, adductor longus; 11, superficial femoral artery; 12, adductor magnus; 13, vastus lateralis; 14, vastus intermedius; 15, stump of sartorius; 16, vastus medialis; 17, stump of rectus; 18, patella; 19, capsule of hip; 20, great trochanter.

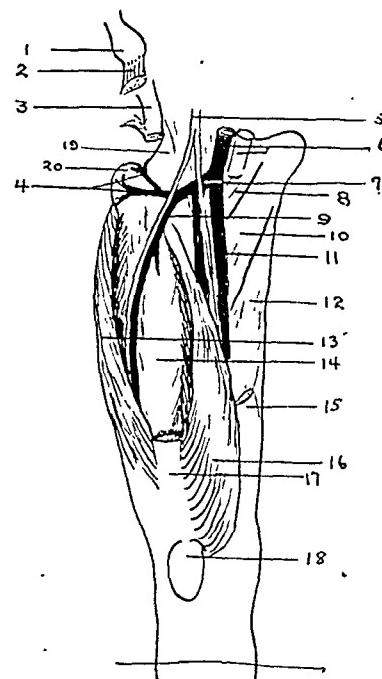


FIG. 43.

these two muscles. (Fig. 34.) The extensor carpi radialis brevis arises in part from the intermuscular septum between it and the extensor communis digitorum and must be stripped from this septum from below upward the desired distance. As the muscles

are retracted, the shiny tendon of the pronator teres will be seen and above this the anterior margin of the supinator. (Fig. 35.) By dividing the fascia over the radial margin of the abductor

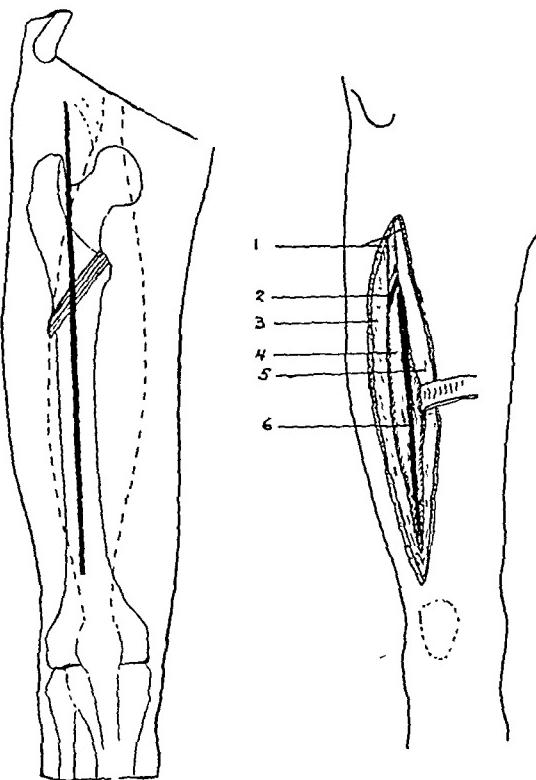


FIG. 44.

FIG. 45.

FIG. 44. Anterolateral femoral approach, line of skin incision; crossing of neurovascular bundle.

FIG. 45. Anterolateral femoral approach. 1, line of skin incision; 2, crossing of descending branches of lateral circumflex vessels and nerves to vastus lateralis; 3, vastus lateralis; 4, vastus intermedius; 5, rectus femoris retracted inward; 6, line of incision through vastus intermedius.

longus, the latter can be retracted inward to expose the radial shaft below the pronator insertion. (Fig. 36.)

*Radius, Lower Extremity.* The lower third of the radius is best approached from the radial aspect, avoiding the superficial radial nerve. This emerges from beneath the tendon of the brachioradialis at the junction of the middle and lower thirds and passes vertically downward. (Fig. 37.) The tendon of the abductor longus pollicis and extensor brevis pollicis are loosened and retracted

backward. For the lower shaft one should pass between the tendon of the brachioradialis and those of the two radial carpal extensors. In the lower extremity it is better to split the tendon of the former

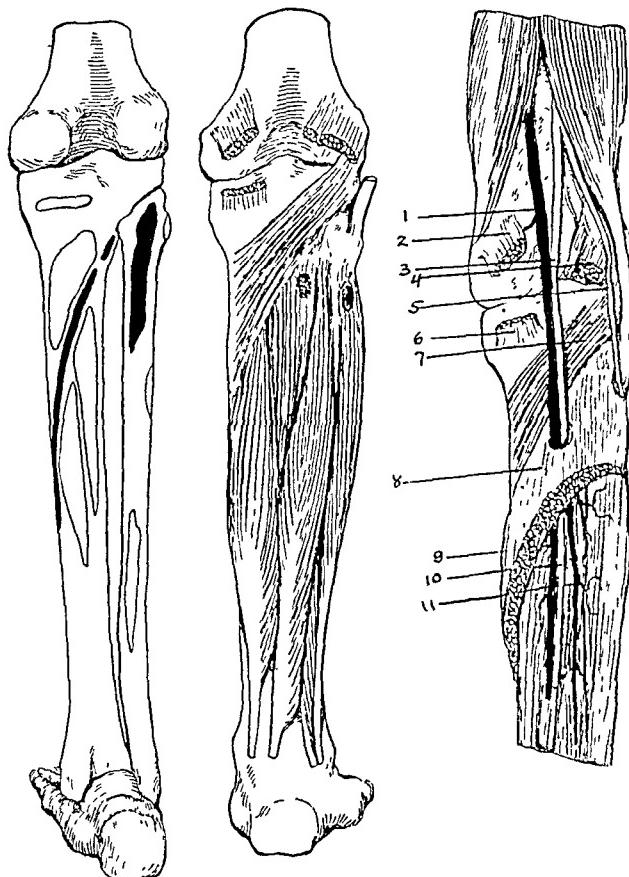


FIG. 46.

FIG. 46. Posterior calf showing muscular origins, soleus in black.

FIG. 47. Posterior calf, deep layer.

FIG. 48. Posterior aspect of knee and upper calf. 1, popliteal artery; 2, gastrocnemius, inner head; 3, tibial nerve (internal popliteal); 4, gastrocnemius, outer head; 5, peroneal nerve (external popliteal); 6, insertion of semi-membranosus; 7, popliteus; 8, soleus (lower portion removed); 9, posterior tibial artery; 10, posterior tibial nerve; 11, peroneal artery.

as it inserts into the base of the styloid and reflect it with periosteum on either side. (Fig. 38.) A firmer closure can be obtained if this is done. In stripping the bone in this region one must avoid the radial vessels which lie close at hand. (Fig. 39.)

## SHAFT OF FEMUR

In exposing the femoral shaft, it is important to injure as few blood vessels and nerves as possible. If a direct lateral approach is

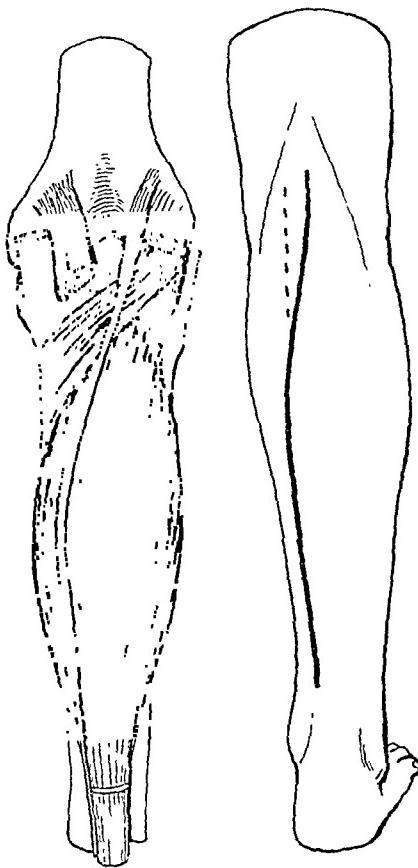


FIG. 49.

FIG. 49. Posterior calf with gastrocnemius removed, showing popliteus, plantaris, soleus.

FIG. 50.

FIG. 50. Posterior calf, line of incision.

used there will be a good deal of bleeding and the fibers of the vastus lateralis lying dorsal to the incision will atrophy from injury to their nerve supply. These difficulties can be avoided if the interval between the vastus lateralis and hamstrings is used with the patient lying prone. It is well to keep anterior to the intermuscular septum to avoid the sciatic nerve. (Figs. 40 and 41.) In dealing with fractures, the anterolateral route is more convenient. This passes between the descending branch of the lateral circumflex vessels

on the outer side and the superficial femoral on the inner and between the branches of the anterior femoral nerve. (Fig. 42.) The rectus femoris is freed on its outer margin and retracted inward.

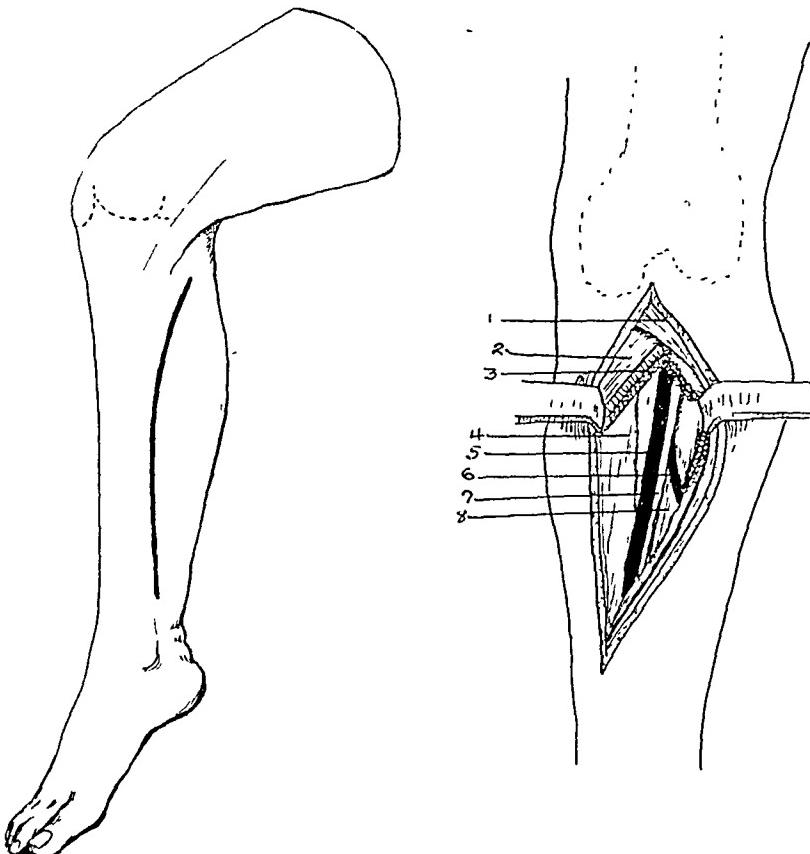


FIG. 51.

FIG. 51. Posterior calf, line of incision from inner side.

FIG. 52.

FIG. 52. Approach to posterior tibial vessels. 1, gastrocnemius retracted; 2, popliteus; 3, soleus divided near its origin; 4, flexor digitorum longus; 5, posterior tibial artery; 6, peroneal artery; 7, posterior tibial nerve; 8, tibialis posticus.

The medial aponeurotic margin of the vastus lateralis can be identified and the muscle retracted outward. In the interval between this muscle and the intermedius the large neurovascular bundle of descending lateral circumflex vessels and femoral nerves can be located crossing in front of the femur just below the lesser trochanter. (Fig. 43.) By splitting the intermedius, the femur can be exposed from the crossing of these vessels to the supracondylar region. (Figs. 44 and 45.)

## LEG

In penetrating wounds of the calf and injury to the vessels and nerves, a direct posterior approach is difficult and very bloody. The posterior tibial and peroneal vessels together with the tibial nerve lie beneath the fascia which separates the deep muscles from the soleus. By detaching the medial and upper attachments of the latter muscle, with the knee flexed and the foot in plantar flexion the soleus and gastrocnemius can be retracted outward giving free axis to this region. (Figs. 46 to 52.)

## DISCUSSION

HENRY C. MARBLE (Boston, Mass.): I recall many years ago, when I was a young surgeon in France, in the next operating room there were other older and younger surgeons. On occasion I was called by the head nurse into the operating room to assist these rather less experienced men, because the wound was wet and because they were not accomplishing what they wanted to accomplish.

I recall then, I being only three decades of age, that the main thing I used to do was to take a knife with me, and would take the approach which they had into the shoulder or into the femur and extend the wound fully its full width upward, and then extend it fully as far below. The resultant exposure was usually about three times as long as the wound which they had. I would then go back to work in my own operating room.

I had quite forgotten that until we were called upon recently to give courses of instruction to young medical officers who were going into the Army. It interested me very much, when I talked with Dr. Darrach, to know that in New York they had much the same experience which we had in Boston, (but up to this time we had not collaborated in our discussions), namely, we bought cadavers and spent a very considerable time in teaching simple anatomical approaches.

Dr. Darrach tells me that in their teaching they utilized somewhere around 40 per cent of their time teaching anatomical approaches. I then thought of the time I spent in teaching anatomic exposures many years ago.

So this is timely and proper. The length of the incision varies with the age of the surgeon. It should vary inversely, but actually it varies directly. Dr. Darrach has shown you exposures, and they are well done. I want to review them very briefly, in a very personal way.

I like his anterior approach to the shoulder. He follows the delta pectoral groove, which is the new expression, then cuts across the outer end of the acromion and lays the wound wide open. His incision is fully six inches long and is dry and clean. That gives a proper exposure to the shoulder.

He showed you the posterior approach. I must confess I have never used that approach but once, and at that time I used it purely on theoretical grounds to drain pus in the shoulder joint which, fortunately, we rarely have.

Dr. Darrach uses that same approach for draining cysts and for getting at the upper end of the humerus. That approach through the back, in which he goes through the teres minor, which is lower, is a nice approach but rarely used.

His approach to the midarm you should all remember, mainly because of the length of his drawings.

The approach to the lower arm I vary a bit. I teach my students that in the posterior approach to the elbow the first thing to do is to isolate the ulna nerve, dissect it free and take it out of the ulna groove, and to have it free. I have found that this is a safer approach. Later when the surgeon reaches the back of the elbow, if the nerve is taken out of the groove and displaced medially, it is best open to injury. So I always say, locate the ulna nerve first; dissect it down until it is passed the elbow, and then take it to one side. That dissection always carries you to the back of the elbow.

The dissections at the head of the radius from the back I vary a bit from the pictures Dr. Darrach has shown, and I make the incision along the end of the ulna. I take the anconeus muscle and reflect it outward. I then expose the radial ulna joint and approach the head of the radius from the back. It is much the same incision, but I am a little more timid than Dr. Darrach is, and I expose it further from the radial nerve which is there open to injury.

The anterior approach I am glad he showed you, because it is an excellent approach. It is used first, in approaching injuries to the front, to the antecubital space.

For instance, in Volkmann's contracture, there are masses of blood under the deep fascia of the forearm which must be approached quickly. I vary the incision very little. He makes an "L" shaped incision but I make the approach on the inner side of the upper arm, across the antecubital space, squarely across, and continue the incision on the outside. I then have the large vessels of the upper arm under view, I have the antecubital space in full view, which can be dissected under the fascia, and by exposing the supinator we re-expose the radial nerve, reflect it outward, and take it promptly down to the whole antecubital space. I cut the little vessels in front of the head of the radius and the latter is then fully exposed. That is an incision which even a junior surgeon in a hospital should know and use in an emergency.

From there I will jump to incisions in the lower arm. I follow them exactly as Dr. Darrach does.

In the lower leg there is one approach which he did not use, and which I daresay he would have gladly added had time permitted, and that is the posterior approach to the hip joint. I think in wartime every surgeon should familiarize himself with the posterior approach to the hip joint. Infections of the hip joint in war are common. This joint needs prompt and complete drainage, and it is best drained through the posterior approach.

I do not know who described it, but I think it was a Belgian; Dr. Darrach will tell you later. It is done through the back, and the main thing is that the sciatic nerve is found and retracted mesially, and the back of the hip joint is exposed through the rear, so the drainage from the hip joint shall be dependent and complete rather than through the front.

I think incisions which I like best are those of Dr. Darrach. They are anterolateral rather than lateral, and go in through the muscle exactly as he does it; and I am sure you will all agree that Dr. Darrach and I advocate strongly a dry route. I like that word. We love a "dry" route. I do not know how you spell "route," but we like it.

There is another thing which I want to say in just a word, and it is that we should familiarize ourselves with the lateral drainage of the knee joint for infection, lateral incisions with the synovia brought out to the skin so that we may have complete drainage of infections of the knee joint.

In the lower leg Dr. Darrach did not say anything about approaches, but I will say that Dr. Fred Cotton taught me one should never approach the front of the lower leg through a straight incision. Someone might say now we are going to have a "dry route" and we are going to be "crooked."

JOHN CALDWELL (Cincinnati, Ohio): I think this paper alone is worth the trip here.

In some operations on the forearm, the posterior approach, will be found very helpful. I like to drape an arm with sterile stockingette, roll it into a doughnut shape, then autoclave it and roll that on the arm from beyond the fingers to the axilla. It covers the arm completely so it is not possible to get under the drapery.

If you have to make an incision for the olecranon, the head of the radius or the outer side of the arm, instead of putting the patient's arm out on the arm board you simply throw the arm across the chest. Take the excess of the stockingette and tie a weight on it (we are accustomed to use a weighted speculum). Let that hang over the side of the patient's body. The arm will be held secure in that position, and you can use the intern and the assistant for some other purpose than to hold the arm in one position all the time.

WILLIAM DARRACH (closing): There is one approach I did not have time to give, which I should like to put on the screen because I think it may come in handy.

One of the greatest troubles we had a few years ago was in what we call the tight calf; that is, wounds of the calf from small bits of hardware, from which there was so much hemorrhage that the calf acted as if it had been blown up with a tire pump. If you went in through the middle of the gastrocnemius and soleus, there was so much old blood and new blood it was pretty hard to see where you were, or pick up the wounded posterior to the vessels or serve. There is a trick to that.\*

\* Dr. Darrach presented three additional slides with the following explanation: (1) The deep layer of the muscles with a hole for the anterior and tibial vessels to go through, and the posterior tibial nerve and artery and the perineal on top of those muscles covered over by fascia. (2) The popliteal artery coming down through the bridge of soleus muscle, with the posterior tibial, perineal and popliteal vessels. This showed the soleus in place, with the plantaris showing. The attachment of this soleus muscle is along the oblique line of the tibia. This showed the line of incision along the margin of the soleus on the inner side. The soleus is attached to the postero-internal margin of the tibia and is not attached below. It goes obliquely across the oblique line of the tibia. If you start down here and separate the soleus from the deep plane, you get in that interval, and with plantar flexion of the foot and knee, they can be reflected outward. Soleus and gastrocnemius muscles can be lifted up and you come right down on the deep compartment. (3) The deep compartment; this is the plantaris. You get free access to the posterior tibial and peroneal vessels. In that way you can tend to any hemorrhage or injury to the nerve with a dry route.

## TREATMENT OF THE PATIENT WITH SPINAL CORD INJURY

JOHN RAAF, M.D.

Associate Clinical Professor of Surgery, University of Oregon Medical School  
PORTLAND, OREGON

**T**HAT injury to neural structures within the spinal canal may result in one of the greatest of human calamities is incontrovertible. Methods to obtain the maximum restoration of lost functions are, however, subjects of much dispute. What to do about the numerous disabling effects of such an injury constitutes the subject of this paper. The opinions expressed are the result of personal observations upon sixty-three patients with traumatic injury to the intraspinal neural structures seen during the last seven years. Two of these patients gave clinical evidence of injury to cervical nerve roots only. Neurological examinations revealed signs which indicated damage to the spinal cord or cauda equina in all others. On the basis of time elapsed from injury to examination by me, the sixty-three cases could be separated into two groups. There were thirty-three acute conditions of the spinal cord. The earliest any of the patients in the acute series was examined following injury was one hour while thirteen days was the greatest length of time which elapsed between injury and examination. Thirty cases were classified as chronic; the time interval from injury to examination ranged from one month to fifteen years. This latter group of cases is included in the study, for even though the initial treatment was not under my supervision I had the opportunity of evaluating the treatment which had been carried out by others during the acute stages. I performed laminectomy for decompression of the cord upon nine patients classified as acute and upon two classified as chronic. In addition, seven others in the chronic group had been operated upon by other surgeons before I saw them.

*Initial Treatment and Examination.* Careful handling of the patient with spinal cord injury to prevent further damage to the cord is obvious. It has been suggested<sup>9</sup> that patients with cervical spinal cord injuries be transported in the face-down position, the argument being that this position forces the patient to keep his neck in

hyperextension and facilitates drainage of vomitus and secretions from the throat. If the patient is placed in this position, great care should be employed to prevent turning of the head to the side.



FIG. 1. Schrieber's pneumatic collar for stabilization of the cervical spine (from Schreiber).

Better still in cases of cervical spine injury is the application at the scene of the accident of Schrieber's pneumatic collar. (Fig. 1.) This ingenious device can be deflated when not in use and, therefore, requires little storage space. When inflated and applied it holds the neck rigidly in hyperextension, thus preventing motion and further damage to the cervical cord. As soon as possible after general shock has been controlled a neurological examination should be done. A neurological examination performed early is important since any change in neurological signs may influence one's decision regarding operation.

Details of the symptomatology produced by lesions at various levels will not be presented since this paper deals principally with methods of treatment. In case there is associated bone damage, the site of injury can usually be determined by discoloration, swell-

ing, acute tenderness, and many times deformity over the point of fracture. When the patient's condition permits, roentgenograms of the spine should be taken, keeping in mind that severe cord damage may occur even though roentgenographic evidence of bony abnormality is absent. A spinal puncture is done to determine whether there is blood in the spinal fluid and whether block in the cerebrospinal fluid pathway is present. The amount of blood and degree of block are not necessarily proportional to the degree of loss of neurological function. Complete and permanent interruption of nerve impulses from levels above the site of injury have been seen with no blood in the spinal fluid and no block. One must be on guard for hysterical paralysis. One patient whom I frequently see has had no less than five hospital admissions with apparent paralysis of the legs and complete loss of sensation from the iliac crests down following minor falls. A few days rest always results in complete restoration of function and return to work. Normal reflexes, lack of disturbance of bladder function, and a tight anal sphincter usually point to the true nature of the condition.

*Laminectomy for Decompression of the Spinal Cord or Cauda Equina.* Shock combated and examinations completed, the surgeon is faced with a most difficult question, namely, whether to decompress the damaged area of the spinal cord. Some surgeons answer the question easily by operating upon none. Some assume the "nothing to lose" attitude and advise operation on all. Others operate if there is a cerebrospinal fluid block and refrain from operation if there is no block. It has never seemed to me that the question can be answered as easily as that. I believe that laminectomy for decompression of the spinal cord is indicated under the following conditions: (1) Presence of neurological signs indicating that the cord lesion is progressing; (2) incomplete cord lesion with evidence of pressure on the cord as indicated by roentgenogram or spinal fluid block; (3) demonstration that the spinal fluid pathway which was open following injury is becoming blocked.

The above criteria have, in my opinion, been listed in the order of their importance. Few will argue against operation when the first situation is present. In the face of progressive neurological signs certainly the spinal cord should be explored. The second criteria is applicable to injuries in the dorsal and lumbar areas but not applicable to a cervical spine injury. Usually pressure upon the cervical cord can better be relieved by traction with the Crutchfield

tongs than by operation. I agree with Munro and Wegner<sup>10</sup> in their statement that patients with cervical cord injury should not be operated upon in the first few days after the accident. By the application of traction rather than resorting to surgery Munro and Wegner have been able to reduce their mortality for this type of injury by 30 per cent. If there is an incomplete cervical cord lesion and the spinal fluid block persists after an adequate trial with traction, decompression of the cord is then justifiable. I present the third criteria with some doubt in mind. Mayfield and Cazan were convinced "that the result of the Queckenstedt test should not influence one appreciably in selecting cases for laminectomy." However, I doubt that few surgeons could resist the temptation to operate when repeated spinal punctures showed a progressive blocking of the spinal fluid pathway. That operation under such circumstances may not bring improvement is demonstrated by the following case:

CASE I. Mr. D. A. C., aged twenty-nine, was caught between a car and a truck while riding a motorcycle on October 30, 1943. He sustained a back injury and his legs were immediately paralyzed. One hour after injury examination revealed a complete loss of motor power and sensation in the lower extremities and roentgenograms showed a crushing fracture of the twelfth dorsal vertebra with no apparent bony encroachment on the canal. Spinal puncture immediately after admission to the hospital revealed clear cerebrospinal fluid with no cerebrospinal fluid block on jugular compression. Spinal puncture was repeated on November 2, 1943, and this time there was no rise of cerebrospinal fluid pressure on jugular compression. On November 3rd, a third spinal puncture again showed a complete block. At operation on November 4th, slight pressure was found on the anterior side of the cord due to mild angulation of the spine. The cord was slightly injected but appeared grossly in good condition. A catheter passed up and down the spinal canal met no obstruction. Since the cord appeared almost normal it was hoped that function would return but seven months have elapsed since injury and there has been practically no improvement.

In this case approximately thirty-six hours elapsed between the demonstration of a complete cerebrospinal fluid block and operation. Perhaps the operation should have been done earlier. The only purpose a laminectomy can accomplish is to relieve pressure on the cord. Therefore, when dealing with dorsal or lumbar injuries, the quicker the operation is done the better, provided the patient's general condition will permit surgery.

One must exercise great care while performing a laminectomy upon a patient with spinal cord injury. The following case illustrates the point. This patient fulfilled the requirements of the second indication for laminectomy and we, therefore, believed that she should be operated upon. Following surgery we regretted our decision.

CASE II. Miss M. L. J., aged eleven, had a convulsion on March 11, 1943. Following the convolution she developed slight loss of motor power in the lower extremities but there was no complete paralysis of any muscle group. Touch and pain sensations were normal throughout the body. The abdominal reflexes were absent. The Babinski, Oppenheim, Gordon, and Schaeffer reflexes were bilaterally positive. Roentgenograms of the dorsal spine revealed compression fracture of the seventh dorsal vertebra. An attempt was made to improve the alignment of the vertebrae by manipulation and traction. Block in the cerebrospinal fluid pathway persisted and operation was advised. The operation was performed on April 7, 1943, with extreme care lest the cord be further traumatized. The cord was found riding over an angulation in the vertebral column opposite the body of the seventh dorsal vertebra. There was pulsation above the point of angulation but none below. When the dura was opened the edges had a slight tendency to retract laterally. The cord appeared normal. The dura was easily closed and a spinal fusion performed. After the patient awakened from the anesthetic sufficiently well to co-operate, it was discovered that she had a complete loss of muscle power in her lower extremities and a decrease in sensation as high as the eighth or ninth dorsal segment. She was taken back to the operating room and the wound reopened. A small bone chip was resting on the dura covering the cord. This was removed and the wound closed. Following reopening of the wound the condition of the patient's lower extremities improved gradually but she never did regain as much motion as she had before surgery.

Pressure from the bone chip may have been responsible for the further loss of function but I am inclined to believe that opening and closing the dura was a more likely cause. In partial lesions of the spinal cord the dura should not be opened unless there is a definite intradural hematoma which requires evacuation. This is particularly true when the dura is under slight tension.

*Reduction of Vertebral Dislocation and Stabilization of the Spine.* Fracture, dislocation, or fracture-dislocation present the additional problem of reduction, realignment, and stabilization of the vertebrae. The site of fracture will largely determine the method. If there is bony damage with or without neural involvement in the cervical

region, the best method of reduction is by traction with the Crutchfield tongs. One should not be content with simply reducing the cervical dislocation; once reduction has been obtained the neck must

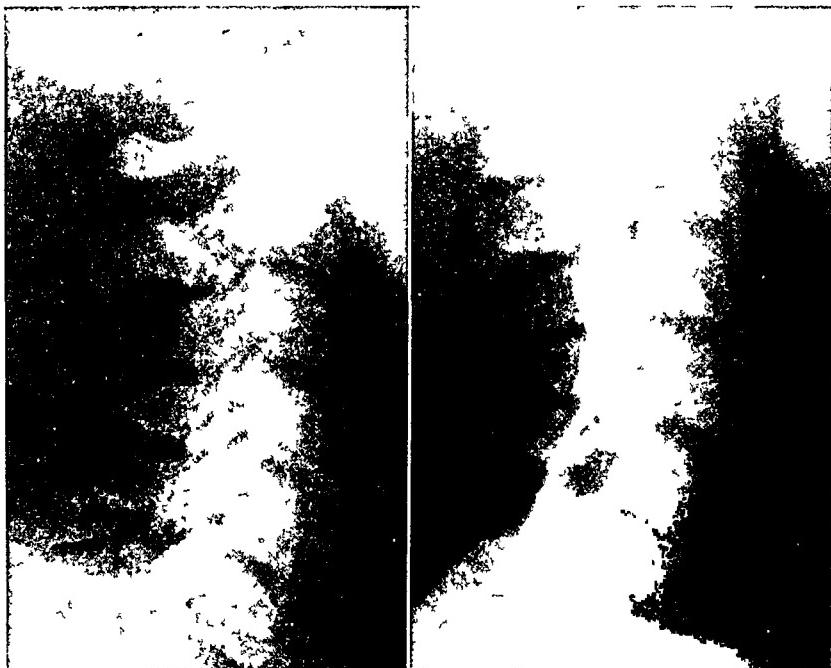


FIG. 2. Case III. Roentgenogram of the cervical spine taken the day following injury. The arrow points to a small chip fracture of the inferior articular process of the fifth cervical vertebra.

FIG. 3. Case III. Roentgenogram of the cervical spine taken two months following injury. There is now a marked forward dislocation of the fifth on the sixth cervical vertebra.

be immobilized for a period of five or six months to prevent redislocation. The following case history illustrates this point:

CASE III. Mr. J. M., aged seventeen, was in an automobile accident on August 9, 1939, at which time he sustained a head injury and was rendered unconscious. When examined approximately twelve hours following the accident the patient was mentally confused. He had a large scalp laceration and bruises about the head. He moved all four extremities. Sensory examination was not possible in his confused mental state. The right Babinski reflex was positive, the left negative. While the examiner was palpating the back of the patient's neck there was an audible pop. Spinal fluid examination revealed a slightly bloody fluid. The dynamics were normal. Roentgenograms of the cervical spine (Fig. 2) showed an excellent alignment of the cervical vertebrae, the only abnormality being

a small chip fracture of the inferior articular process of the fifth cervical vertebra. During the next few days the patient remained mentally confused and difficult to handle. When he became mentally clear, approximately a week following the accident, he complained of slight numbness of the hands. The numbness subsided and he was dismissed from the hospital three weeks after injury. The patient was next seen on October 10th, two months following injury, at which time he came to the office complaining of stiffness in his neck and inability to retract his head as far as usual. Roentgenograms of the cervical spine showed a marked forward dislocation of the fifth cervical vertebra on the sixth. (Fig. 3.) With the redislocation no new neurological signs had developed. The patient was advised to return to the hospital for application of traction but treatment was refused.

Obviously the patient sustained a fracture-dislocation of the cervical vertebrae at the time of his injury which was accidentally reduced by the examiner. When the roentgenograms taken the day following injury indicated normal alignment of the vertebrae, attention was subsequently turned entirely toward the cerebral injury. Measures should, of course, have been taken to stabilize the cervical spine before he was dismissed from the hospital.

When accompanied by neural injury reduction of a fracture in the dorsal or lumbar spine may be accomplished by gradual hyperextension. If the injury is in the dorsal region, the patient's position in bed is reversed, that is, his head is placed at the foot of the bed and his back is placed across the convex surface which is formed when the knee rest is elevated. Gradually the convexity of the bed can be increased until reduction is accomplished. If the fracture is in the lumbar area there may not be room enough between the elevated portion of the bed and the foot of the bed to accommodate the patient's upper torso, head, and neck. In such a case hyperextension is accomplished by placing a blanket roll underneath the mattress to form the convexity of the bed. If articular processes are locked so that reduction by hyperextension is not possible, an operation with unlocking of the processes as advocated by Barber becomes necessary. Once reduction has been accomplished, a plaster of Paris jacket to hold the position might seem desirable but is definitely contraindicated in complete transverse lesions of the cord or cauda equina because of the danger of bedsores.

Following laminectomy for decompression of the cord one must be particularly careful to provide adequate support for the back

before the patient is allowed to sit up, for in these cases the ligaments which have been torn and the articular facets which may have been fractured are still further weakened by the laminectomy. The following is an illustrative case:

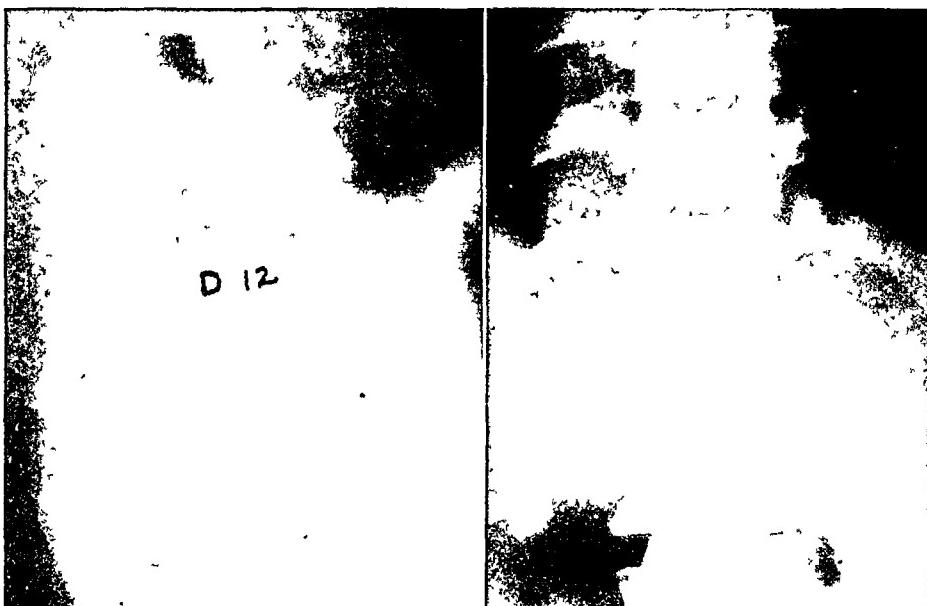


FIG. 4. Case iv. Lateral roentgenogram of spine taken before laminectomy. There is compression fracture of the twelfth dorsal vertebra.

FIG. 5. Case iv. Anteroposterior roentgenogram of spine taken before laminectomy.

**CASE IV.** Mr. W. N. W., aged twenty-eight, injured his back in an automobile accident on May 2, 1943, and was immediately paralyzed from the waist down. Roentgenograms showed a fracture of the body of the twelfth dorsal vertebra. (Figs. 4 and 5.) A laminectomy was done. The dura was found to be torn and the spinal cord opposite the twelfth dorsal vertebra completely destroyed. The patient was kept flat in bed during the six weeks which he remained in the hospital. Because of his complete sensory paralysis from the umbilicus down he was not placed in a cast nor was he provided with any type of metal back brace. He wished to return home and was allowed to do so. He was seen on January 15, 1944, eight and one-half months after injury, when he returned complaining of pain in his back. Roentgenograms (Figs. 6 and 7) revealed marked displacement of the eleventh dorsal vertebra on the twelfth.

This patient should have remained flat in bed for approximately three months. If roentgenograms then showed adequate bone repair,

he could have been provided with some type of back brace and allowed up. In some of these cases spinal fusion may be desirable but I do not believe that fusion should be done at the time of the



FIG. 6. Case iv. Lateral roentgenogram of spine taken eight and one-half months after laminectomy. There is marked anterior displacement of the eleventh dorsal on the twelfth.



FIG. 7. Anteroposterior roentgenogram of the spine taken at the same time as one shown in Figure 6.

laminectomy. Shortly after injury when the laminectomy is done the tissues are usually so hemorrhagic and torn that spinal fusion would be difficult and too time-consuming.

*General Care of the Patient.* Every precaution must be taken to prevent bedsores. In my experience the best type of bed is an air mattress. Bradford frames and boards under the bed not only are unnecessary but are actually to be condemned. The air mattress must be inspected at least twice daily to be certain that it is adequately inflated. The only bedsore I have ever seen develop while the patient was on an air mattress resulted from the mattress being insufficiently inflated to keep the hip off the hard bed underneath. Pillows must be placed under the calves of the legs to prevent sores from developing on the ankles and heels. The prevention of footdrop is best accomplished in the following manner: Shave the lower legs, put on a pair of women's silk or thin cotton stockings as high as

the knee and apply a coat of shellac, which sticks the stocking to the leg. Enough of the toe of the stocking should be left projecting beyond the patient's toes so a cord can be tied about it. The cords

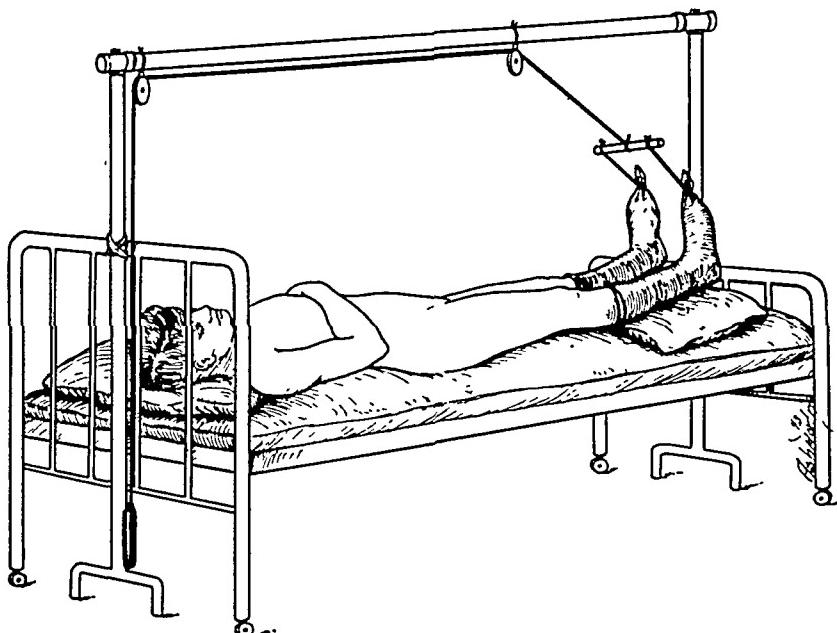


FIG. 8. Method of preventing footdrop.

from the toes of the stockings are attached to a crossbar from which another cord passes up over a pulley on an overhead frame. (Fig. 8.) Weights at the head of the bed keep the feet in dorsiflexion. The patient should be turned in bed every two hours. While the patient is on his side or abdomen the cords to the toes of the stockings can be released. A cradle is necessary to prevent bed covers from resting on the toes. The patient's skin should be gently massaged every three or four hours and passive exercises given the paralyzed extremities. In case a reddened area appears on the skin it should be painted with tincture of benzoin.

*Care of Paralyzed Bladder and Bowel.*—The following methods have been employed in caring for the acute neurogenic bladder: (1) Non-interference with distention and overflow, (2) manual expression of urine until "automatic" bladder develops, (3) intermittent catheterization, (4) continuous drainage through an indwelling catheter directly into waste bottle, (5) continuous drainage through indwelling catheter with closed irrigator system or

tidal wave apparatus, (6) suprapubic cystotomy, and (7) perineal urethrostomy.

The method of non-interference with distention and overflow should not be used except for very short periods of time when other facilities are lacking, for respiratory and cardiac action may be embarrassed and a bladder so overdistended may not regain its tone.

I have not used manual expression of the urine because adequately trained personnel who can be depended upon to carry out such a maneuver carefully has usually been lacking. Also when this procedure is employed there is a possibility of rupturing the bladder<sup>2</sup> and the wet bed which is usually present makes the occurrence of bedsores likely.

Intermittent catheterization is to be condemned because of trauma to the urethra and introduction of infection into the bladder. Continuous drainage with an indwelling catheter directly into a waste bottle has all the disadvantages of the inlying catheter and none of the advantages of the tidal wave apparatus.

As soon as possible after the patient's arrival in the hospital a tidal wave apparatus is attached to an indwelling catheter in the bladder. I have usually used the apparatus as described by Munro<sup>8</sup> or as modified by Hesser, even though it is recognized that an indwelling catheter may produce urethritis, balanitis, and epididymitis. Another distinct disadvantage of this method is that for a tidal wave apparatus to function properly someone who understands its operation must check it frequently. If this type of drainage is to be used, the following suggestions are made: (1) The use of a Foley catheter so that all bands encircling and constricting the penis may be eliminated; (2) a catheter small enough to allow urethral secretions to escape around it; (3) twice daily manual irrigation of the bladder with boric acid to be certain the bladder is washed out; (4) removal and resterilization of the whole apparatus once a week; (5) the administration of small doses of urinary antiseptics such as methenamine or mandelic acid, continuously given over a long period of time.

A method of bladder drainage which is very satisfactory and deserves more widespread use than it generally has been accorded is suprapubic cystotomy. This method of drainage is very easy to institute through a small suprapubic incision. The indications for its use are (1) old or very ill patients, (2) marked urinary tract

infection, (3) lack of adequate personnel which prevents careful checking on tidal wave apparatuses, (4) inability to tolerate a urethral catheter and (5) transference of patients from one hospital to another which requires a period of several days. Hinman in discussing the problem among soldiers goes so far as to state that he believes a suprapubic cystotomy should be done at the outset of acute retention when the injury is severe, provided it will be days or weeks before the soldier reaches a place where good management will be given.

I have had no experience with perineal urethrostomy as advocated by Lewis. It is claimed that this method is advantageous because the patient can lie on his abdomen part of the time and drainage is better than with a suprapubic tube. One wonders whether the disadvantages, namely, that the catheter passes through the posterior urethra and that for the average physician the insertion of the catheter would be more difficult than performing suprapubic cystotomy, would not outweigh the advantages.

As time goes on the bladder will either recover or become a chronic neurogenic bladder. In the latter case, if the cord has been injured above the conus the bladder will be governed by a simple spinal reflex. Stretching of the bladder wall is the stimulus for bladder contraction and evacuation. The patient can usually adapt himself fairly satisfactorily to this type of bladder activity, but if the contractions are too frequent and the patient dislikes an incontinence bag, he may be more comfortable with permanent suprapubic drainage. If the injury is in the region of the conus or cauda equina, the bladder has no spinal reflex activity and high residual with dribbling incontinence may result. With this type of bladder three measures are available which may aid evacuation; (1) Evacuation may be accomplished by periodic manual suprapubic pressure with straining. (2) In those patients in whom the internal sphincter is spastic, transurethral resection of the internal sphincter is indicated. (3) Finally, a certain number of patients may require permanent suprapubic drainage.

Following a spinal cord injury the patient may have fecal incontinence, but severe constipation is usual. Cathartics should be avoided and an enema given every second day. A rectal examination should be done at least once a week to check for fecal impaction.

*Rehabilitation of the Patient.* Life for most patients following spinal cord injury is extremely difficult and every available measure

must be taken to make them more comfortable. Massage, warm baths, and underwater exercises should be administered. In some cases the reflex activity of the spastic limbs is such that massage cannot be administered. If the extremities become too spastic, the patient may be more comfortable following intraspinal section of the motor roots which supply the affected muscles. The orthopedic surgeon may aid greatly by stabilization of joints, transplantation or lengthening of tendons and application of braces. Some of these patients present the problem of nerve root pain. Cutting specific sensory roots may bring relief but frequently cordotomy (section of the anterolateral spinothalamic tracts) is preferable.

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#### DISCUSSION

HARRY E. MOCK (Chicago, Ill.): Lacking the opportunity of reading Dr. Raaf's very excellent paper beforehand, I am limiting my discussion to the expression of certain personal opinions derived from the treatment of the average number of cord injuries coming to the hands of the surgeon with a fairly extensive traumatic service.

Back injuries of all descriptions are scattered throughout the land. In my experience less than 2 per cent of these back injuries give signs of cord injury. Considering the country as a whole the general physicians and surgeons located in the County seats and the nearby towns see just as many and probably more cases of cord injuries than do the neurosurgeons in the great medical centers. The picture presented by immediate paralysis

from the neck or waist downward in a healthy man or woman who has just sustained an accident is an overwhelming catastrophe. There are problems which must be met immediately by the physician or surgeon first seeing the case if the patient is to survive or is ever to walk again. The essayist has portrayed these steps of management so excellently that repetition is superfluous. However, there are certain points that are controversial or have not been sufficiently stressed. Otherwise, we would not see so many of these patients going practically untreated.

If the paralysis develops immediately following the injury and is complete and corresponds to that segment of the cord adjacent to the fracture or dislocation in the spine, one is justified in assuming that the cord has been injured. The x-ray will show the presence of the fracture or dislocation but it does not reveal the amount of compression or the extent of compression of the cord by displaced fragments. A spinal puncture with clear or bloody fluid obtained or with a Queckenstedt test for a block positive will not show the extent of cord injury. In such cases I believe it is logical to assume that the cord may be crushed or transversely severed or it may be severely compressed by a depressed arch or other fractured fragment. If the first situation exists, the case is hopeless so far as the paralysis is concerned; but if the second situation only is present, relief of this bony pressure on the cord may partially, although seldom completely, cure the paralysis. Again, the earlier this mechanical constriction of the cord can be removed, the better chance has the patient to recover from his paralysis. Therefore, the only logical procedure is to do a laminectomy, call it an exploratory laminectomy, to see if early relief from cord compression cannot be obtained. The longer such compression remains on the cord, the greater the degenerative reaction in the neural tissue.

In my opinion, this is the view of the majority of general surgeons, familiar with major trauma cases, especially interested in the surgery of trauma. It is not the view held by many neurosurgeons who in recent years have been preaching delay in laminectomy especially if a spinal block is not demonstrated.

If the paralysis develops slowly over a period of minutes or hours following a back trauma, it is logical to assume that concussion or contusion of the cord with edema or a hemorrhage is the condition present rather than pressure from a bony fragment. Bear in mind that this delayed paralysis may be due to some accident following lifting of the patient onto the x-ray table or similar movement. Ruling this out, then one is justified in delaying laminectomy; for in the majority of these cases, the edema will subside, the hemorrhage will absorb and recovery will follow within a few weeks or months.

Every patient with paralysis, whether subjected to laminectomy or not, should be placed upon an air mattress just as early as possible. Every

effort must be made to avoid decubitus ulcers. Within the year I have seen a patient completely paralyzed due to a fractured eighth dorsal vertebra, encased in a body cast. When the cast was removed three weeks later, large decubitus ulcers were present over the knuckle of the fracture, the sacrum and both ilia. For the same reason plaster or mechanical splints to the lower extremities to prevent foot drop or faulty positions should be avoided. Muslin hammocks, ropes, pulleys and weights and frequent exercises should be used to control this situation.

When an indwelling catheter for tidal drainage or otherwise is used, every precaution must be taken to avoid infection. The catheter should be self-retaining by means of a balloon or a mushroom on the bladder end, rather than retained by dirty adhesive applied about the glans penis. If cystitis develops and recurring attacks of ascending infection occur, cystotomy is the safest method of caring for the bladder.

Finally, physical therapy started early and persisted in for months and even for two or three years will eventually reward the surgeon and the patient with a certain amount of function in many of these cases.

E. P. PALMER (Phoenix, Ariz.): Any patient who has been involved in a serious accident should be treated as though he had an injury of the cord. The unconscious patient cannot tell you that he cannot feel or that he cannot move his extremities, yet he may have a serious involvement of the cord.

Therefore, that patient should be handled with care, the same as a patient is handled who is known to have an involvement of the cord, transported carefully to the hospital and treated as though he had an injury of the cord, until it is proved otherwise.

I cannot agree with the theory that these patients must have a delay of weeks or months before they are operated upon. Years ago I carried out a series of experiments on animals and we proved that compression of the cord carried on over six hours resulted in permanent injury. There is no regeneration of spinal cord tissue. When it is destroyed it does not regenerate.

Therefore, if you are going to have beneficial results after injury to the cord, and an operation is indicated, the operation should be done within the six-hour period. If you wait thirty-six hours, as Dr. Raaf did, or wait three weeks to six months, before operating upon these patients, you are going to have fatal results.

JOHN CALDWELL (Cincinnati, Ohio): A few cases follow that illustrate some of the points that have been mentioned:

We have observed at the Cincinnati General Hospital a series of six patients who have had spinal injuries with cord lesions, in which the x-rays have been entirely negative; they have shown nothing at all. Four of those patients had complete transverse lesions, yet the x-ray picture was entirely negative, and the picture was taken right away.

After death necropsy of these four patients showed there had been a complete transection of the cord by displacement of a vertebra, but in the handling of the patients bringing them in, there had been immediate reduction.

That, to my mind answers fairly conclusively this question of immediate laminectomy to relieve pressure. There is no surgeon who gives quite as prompt relief as that. These patients are just dragged out from a wrecked automobile or moved about in an ambulance and have a displacement of the vertebra, which has been so completely reduced that the x-ray is entirely negative.

Two patients survived, one with almost complete symptoms. He was emaciated to a shadow; he could not lift his arms. He would stand up and walk with a shuffling gait if he was helped to his feet. He could not feed himself. He was in a most pitiable condition. That was present three years later.

The other patient, a lineman, twenty-nine years ago, fell out of a tree and had an incomplete lesion, probably a traumatic hematomyelia. He had dissociation of sensation. Some years later he made a fairly complete recovery and could get about. In fact, he went back to work as a lineman, but the disassociation of the sensation persisted to such an extent that three years later he stood in front of a great fire and burned both of his shins without knowing it. His functional recovery, however, was fairly good.

The following is another case illustrating a different phase: A young woman struck by a rapidly moving automobile had a crushed chest, a lateral dislocation of the sixth and seventh dorsal segment, a bad head injury and terrific shock. She was brought in in such shape that there was nothing to do; we could not even take an x-ray nor do a spinal puncture.

Upon examination it was found that one leg was completely out, and within a few hours the other leg's motion and sensation disappeared. She rapidly developed bladder symptoms.

On account of her general condition nothing at all could be done for her. The position of the vertebra showed that there was urgent demand for an attempt to reduce the displacement, but her condition would not permit that. Before the week was out she developed a complete lobar pneumonia from which she convalesced. At the end of that time an attempt was made at reduction of her spinal deformity, and nothing at all was accomplished. We planned a late laminectomy with her, but before we got started on it she began to improve.

The final result was that at the end of three months or so she regained complete bladder function; she had quite a good gait finally with slight spasticity. Several years later she could dance and do practically everything she wanted to do, and she finished a university course. If I had done a

laminectomy on her, I think I would have thought I had accomplished quite a surgical triumph.

JOHN RAAF (closing): My plea is for the development of some rationale for laminectomy in these cases. I wish I could develop the attitude that all patients should be immediately operated upon because this attitude would take a terrific strain off my judgment.

However, I do not believe all patients with spinal cord injury should be indiscriminately subjected to surgery. As I stated previously, Munro found that in cervical cord injuries conservative treatment netted 30 per cent lower mortality.

In the dorsal and lumbar regions if there is evidence of an incomplete lesion of the spinal cord, and if a block is present, I believe operation should be carried out.

## PENICILLIN THERAPY\*

WALTER S. PRIEST, M.D.

CHICAGO, ILLINOIS

**T**HE discovery of penicillin is usually described as accidental. But this is not entirely true. For fifty years prior to Dr. Alexander Fleming's recognition of the possible significance of the lytic effect of a contaminant mold on an agar culture of staphylococci, many bacteriologists had observed this phenomenon. In 1900, Emmerich<sup>1</sup> isolated an antibacterial substance from *Bacillus pyocyaneus* which was later found to check the growth of diphtheria bacilli *in vitro* and to exert a favorable action on the clinical disease. However, the true importance of this phenomenon of antibiosis was overlooked for the time being.

In September, 1928, while examining some agar plates of staphylococcus, Dr. Fleming, (a bacteriologist at Oxford University) noted complete inhibition of growth in the neighborhood of a contaminant mold which he identified as *Penicillium* of the *Notatum* group.<sup>2</sup> Had it not been for Dr. Fleming's many years of interest and research in antibacterial agents, it is possible that the significance of this observation would have been overlooked. Following it up he found that the mold, grown on the surface of nutrient broth, produced in the broth a powerful antibacterial substance. By 1932,<sup>3</sup> he had demonstrated its action *in vitro* against Streptococci, Staphylococci, Pneumococci and *Corynebacterium diphtheriae* and had shown it to be non-toxic for animals and non-irritating to the human conjunctiva. He called the substance Penicillin and suggested its use locally in clinical infections caused by the above organisms.

Strangely enough these suggestions were not followed up until after Dubos in 1939<sup>4</sup> published his observations on the antibacterial effect against Gram-positive cocci of an extract of a soil bacillus. This work led to the development of tyrothricin and gramicidin and stimulated Dr. H. W. Florey, also of Oxford, to re-investigate penicillin and work out methods for its production and purification

\* From the Department of Medicine, Wesley Memorial Hospital and Northwestern University, Medical School, Chicago. Part of the Penicillin used on patients discussed in this paper was furnished by the Committee on Chemotherapeutics and Other Agents of the National Research Council and part by the Penicillin Research Committee of Northwestern University Medical School.

in order to make further clinical application possible. By 1941, he had accumulated enough data on its potential clinical usefulness to enable him, during a visit to the United States, to interest the National Research Council and the Department of Agriculture to undertake the studies of the mold's growth characteristics and possibilities for large scale propagation. To Dr. Coghill and Dr. Mayer of the Northern Regional Research Laboratory at Peoria belong much of the credit for this work. To the pharmaceutical houses, and manufacturers of biologicals and chemicals belong the credit for the actual attempts at mass production.

At first it was believed that the mold could be satisfactorily grown only in small amounts of nutrient media. This resulted in the type of production in which the mold is grown in individual flasks containing not more than two liters of media each. Recovery of 5,000 to 10,000 units per flask was considered a good yield. Obviously it was physically impossible to produce enough by this method to supply both military and civilian requirements. Intensive efforts on the part of mycologists, chemists and engineers connected with fermentation and commercial chemical industries resulted in the perfection of methods of growing the mold in submerged cultures in huge tanks of broth or on bran. The increased production made possible by such methods is responsible for the civilian availability of penicillin today.

From 1941 to May 1st of this year clinical and laboratory research on penicillin was under the direction of the committee on Drugs and Therapeutics of the National Research Council. As indications of specific clinical usefulness developed the military forces requisitioned all but a very small amount of the total production. That which was left was allocated to selected investigators throughout the country and from their studies have come our present knowledge of dosage, methods of administration, rate of absorption and excretion and clinical applications of the drug. As experience expands this knowledge will be extended and our present concepts may be modified. However, enough definite information is at hand to remind us that it is not a cure-all and the present tendency on the part of some clinicians to use it in the treatment of everything just because it is now available is unworthy of men of science.

Penicillin itself is an acid which reacts chemically to form salts and esters. The sodium salt is the one at present available, although

calcium barium and ammonium salts have been used. The penicillin unit is an arbitrary measure based on a plate assay method developed by Dr. Florey, and is referred to as the Florey or Oxford unit. The pure salt is colorless but to obtain it in this form is at present impractical and apparently unnecessary. The yellowish color of the commercial product is due to harmless impurities and varies to some extent. This need cause no concern since freedom from toxicity and pyrogens, and a potency within 25 per cent of the stated level is guaranteed by rigid requirements of the Federal Drug Commission. Most products will actually assay higher than the potency indicated on the label. Assays in our own laboratory of the product of several manufacturers revealed only one instance of the converse of this.

The sodium salt is highly soluble and markedly hygroscopic, hence must be kept from contact with moisture until ready for use and at a temperature around 5°c. Under these conditions potency is not affected for at least three months. For so potent a therapeutic agent toxicity for man is practically nil. We have given 500,000 units in 100 cc. of saline intravenously in less than thirty minutes without significant reaction. Such dosage is still far below the toxic level for animals in addition to being unnecessary for the treatment of any condition so far known to be amenable to penicillin. Rarely urticaria may develop during the administration of therapeutic amounts. If this occurs, treatment should be discontinued since an occasional case of exfoliative dermatitis has been observed.

Rapid absorption and excretion is characteristic of the drug. Since it is destroyed by acid and organisms of the colon group it cannot be given by mouth or rectum. Within five minutes or less after intravenous administration it appears in the urine and after a short lag the rate of excretion parallels that of administration. Approximately 60 per cent of the amount administered, whether a single dose, multiple doses or continuous injection, is excreted by the kidneys. The fate of the remainder is not yet entirely known. It has been found in high concentrations in bile thus suggesting its use in certain biliary tract infections. It also appears in saliva but not in tears or pancreatic juice.<sup>5</sup> Serum levels rise rapidly after intravenous injection, somewhat more slowly after intramuscular and much slower after subcutaneous injection. For a given single dose serum concentration is higher after intravenous injection

than by any other method. On the other hand, while serum concentration does not reach the same height after intramuscular injection the level is maintained longer (thirty to forty-five minutes) and decreases more gradually. Following subcutaneous administration no penicillin appears in the blood for an hour and a half to two hours and the maximum concentration is much the lowest but, such as it is, remains the longest since excretion in the urine is prolonged. Since only traces are found in serum two and a half to three hours after a single intravenous or intramuscular injection, the method and frequency of administration become important in planning therapy. From the serum level standpoint, continuous intravenous therapy is most desirable, and for severe infections, gravely septic patients and in treating infections with organisms of low penicillin sensitivity this is the method of choice in our opinion. It has the obvious disadvantage of requiring fairly close supervision by an intelligent nurse and the prompt availability of resident physicians skilled in intravenous therapy.

During the past year we have had considerable experience with this method and have found that, properly anchored in a small vein of the hand, forearm, foot or ankle, using a No. 21 gauge needle,  $1\frac{1}{4}$  inches long, the patient experiences little inconvenience, is able to move about, feed himself and even get out of bed. Most of our patients learned to regulate the rate of flow themselves and only one had special nurses. This coincides with the experience of Dr. W. E. Herrell of the Mayo Clinic. We have been able to maintain continuous flow at 10 to 12 drops a minute for fifteen days without removing the needle. By this means 100,000 to 400,000 units or more may be administered in a liter of solution per twenty-four hours thus avoiding excessive fluid intake if necessary. No decrease in potency of the solution was observed at the end of twenty-four hours. Pyrogen reactions have been encountered possibly due to continued use of the same tubing. No harm has resulted from these if the tubing is promptly changed, which can be done without removing the needle from the vein. Meticulous preparation of the intravenous set in accordance with the technic approved for blood banks would possibly eliminate these reactions. Within the past few weeks we have not had pyrogen reactions although using the same brands of penicillin, which tends to confirm the suspicion that there might have been an error in the technic of washing the rubber tubing. Venous irritation does occur frequently

but in our experience this subsides and the veins return to normal function in most instances. Actual thrombosis has been rare.

In summary it may be said that the administration of penicillin is, at present, a hospital procedure and that the continuous intravenous drip method is preferable whenever feasible since a more nearly constant serum level can be maintained. However, actual clinical results, notably in the treatment of gonorrhea, indicate that for many infections, fluctuations in the serum penicillin level are unimportant in obtaining a favorable result. Hence, the most generally practical and effective method of administration will probably be by intramuscular injection at three-hour intervals around the clock, started off by an intravenous injection of a dose two to three times that of the subsequent intramuscular dose. It is vitally important that the three-hour schedule be adhered to. Some good results have followed administration every four hours, but this should not be depended on in critical cases. We believe that repeated intravenous injections have manifest disadvantages and no advantage compared with the two methods outlined above.

The most frequently used concentration for single intravenous or intramuscular injections is 5,000 units per cc. of diluent which may be normal saline, 5 per cent glucose in saline, or distilled water. Recently, however, we have had patients complain of a burning sensation at the site of intramuscular injections when such concentration was used. This was not experienced when a concentration of 16,000 units per cc. was used.

We have had one occasion to give penicillin by continuous hypodermoclysis over a period of several days in concentrations of 200 units per cc. No discomfort other than that accompanying similar administration of normal saline was observed. However, in our opinion, this method should not be used except in the rare instance in which the patient "has no veins" and objects to repeated intramuscular injections.

In normal individuals penicillin does not pass into the subanachnoid space from the blood stream.<sup>6</sup> Therefore, to be effective in meningitis it must be given intrathecally as well as intramuscularly or intravenously. The usual intrathecal dose is 10,000 to 20,000 units. However, we have given 50,000 intrathecally without unfavorable reaction. There is no point in using penicillin routinely in meningococcic meningitis except in sulfonamide resistant cases. However, it is the drug of choice when a streptococcus or staphylococcus is the offending organism.

All hospitals at present designated as penicillin depots have copies of dosage tables as well as the indications and contraindications for the use of penicillin compiled by the National Research Council in accordance with clinical experience so far. To these you are referred for detailed discussion. Additional diseases in which penicillin is effective will no doubt be added to this list as our experience broadens.

Assuming that you have decided to use penicillin in a given case and since the currently available ampoules contain 100,000 units, a good rule of thumb is to administer 100,000 units in eight approximately equal doses every three hours around the clock. If clinical response is favorable, this dosage may be continued until temperature is normal then reduced to 50,000 units per twenty-four hours for the next five to seven days. If the response is not favorable, the twenty-four hour dose should be increased to 200,000 or even 400,000 units and continuous intravenous drip employed if possible. Failure to get a prompt favorable response to these doses indicates that either the causative organism is not penicillin sensitive or some localized abscess has not been drained, or the disease is due to mixed infection, or is bacterial endocarditis. Critical clinical judgment must then dictate what course to pursue. As an example of an immediately favorable result may be cited the first case of sulfonamide resistant pneumonia that we treated. Our supply was very meager and only 40,000 units were given the first twenty-four hours but this was sufficient to cause an immediate fall in temperature from 103° F. to normal with associated clinical improvement. A more recent patient illustrating the apparent need of larger dosage was admitted after a week of chills and fever following attempted abortion. Large doses of sulfonamide had been ineffective and her condition was critical; 100,000 units of penicillin by continuous intravenous drip were given the first twenty-four hours. The temperature dropped to normal but started up again before the twenty-four hours were up, so 200,000 units were given the second twenty-four hours. The temperature dropped to normal and remained so and she was discharged on the seventh day. Uterine culture showed hemolytic streptococci. Still another problem is illustrated by a child who developed signs of peritonitis following operation for a ruptured appendix. She was almost moribund when penicillin was started. Slow improvement resulted, the temperature became normal and it looked as if she was out of trouble, but the temperature again became septic in character. Penicillin was again given, the

temperature came down but the pulse and general condition remained unfavorable. Signs of abscess developed and drainage will have to be done before recovery can be expected. We have observed this tendency for the temperature to become normal under penicillin therapy even though other clinical signs are not equally favorable, and it demands a careful search for abscess formation or some other condition, such as thrombophlebitis or an associated organism not affected by penicillin.

The local use of penicillin has particular application in the surgery of trauma. Experience here is not so definite as in systemic infections. Some observers report favorable reports; others do not. Apparently the most favorable results have been obtained in acute situations, notably in empyema, suppurating joints, sinus tracts, osteomyelitis and infected wounds, in which the infecting organism is known to be sensitive. In treating empyema, joints or abscess cavities, aspiration or drainage must first be done, then the cavity partially filled with penicillin solution in a concentration of 250 to 500 units per cc. Repeated fillings daily, twice daily, or in rare instances oftener are necessary. Therapy should be controlled by daily bacteriological smears. Recently we administered penicillin intramuscularly in doses of 25,000 to 15,000 units every three hours to a patient who had multiple boils, one of which had been incised and drained just before injections were started. The abscess became sterile within twenty-four hours without local application of penicillin or other antibacterial agents. Boils in process of formation did not suppurate. The conjunctive will tolerate solutions of 250 to 500 units per cc. In very early acute osteomyelitis, before sequestrum formation, apparent cures without surgery have followed parenteral administration of penicillin. But once sequestrum or a draining sinus has formed, it is futile to use penicillin unless proper surgery is performed. The resulting wound offers a chance to use the drug incorporated in a paste made of lanette wax and vaseline.<sup>7</sup> In any gutter type of wound this has been found an effective means of application.

Other conditions of particular interest to surgeons of trauma in which penicillin has been used with good or favorable results are:

*Surface Wounds and Burns.* Sterilization of penicillin sensitive gram-positive organisms has been obtained by dusting with 1 per cent penicillin in sulfanilamide powder. If signs of sepsis develop, parenteral administration should be combined.

*Deep Wounds.* Fairly extensive experience in battle areas<sup>7</sup> indicates that several weeks' hospitalization may be saved and generally better end results obtained by closing such wounds immediately without extensive débridement. One or more rubber tubes are inserted directly into the wound or through stab incisions and allowed to project beyond the dressings. Tight suturing in layers is to be avoided and the sutures should not be placed too near the skin edges. Through the tubing 3 to 10 cc. of penicillin solution containing 250 units per cc. are injected twice daily for four days. Injection of too much solution is to be avoided. Sutures should not be removed too soon.

*Cellulitis.* Some of the early dramatic results were obtained in treating cellulitis with or without bacteremia since the common organisms are streptococci and staphylococci. Definite collections of pus should be evacuated. We have not personally observed cases of Ludwig's angina treated with penicillin but it would seem to be worth using in this infection.

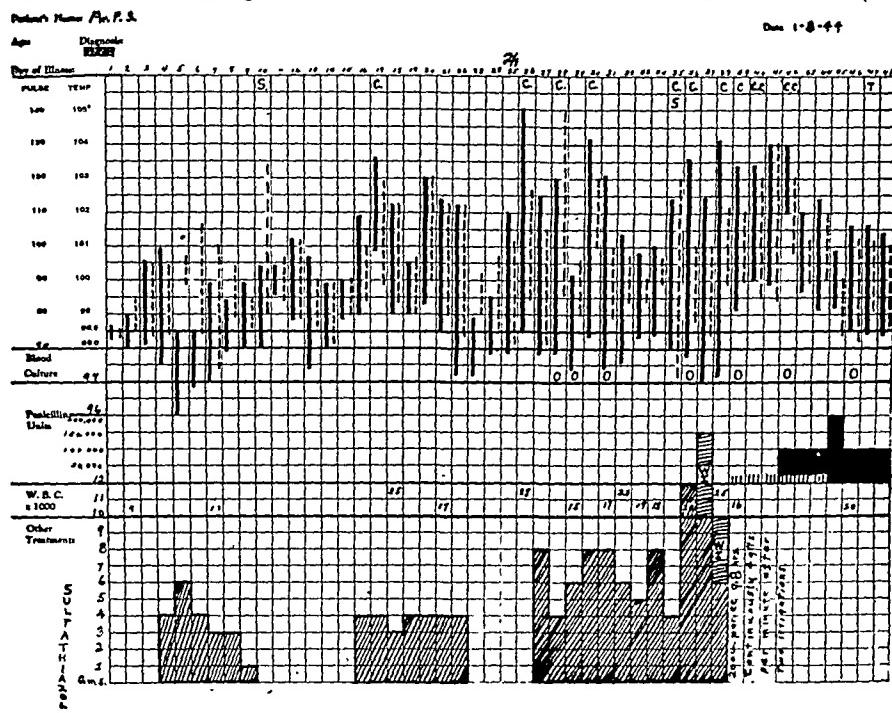
*Infections of the Hand and Palmar and Tendon Sheaths.* Local instillation of solutions by means of tubes plus parenteral administration has given encouraging results.

*Cavernous Sinus Thrombosis and Infected Thrombophlebitis.* Since the common infective organism in cavernous sinus thrombosis is staphylococcus, parenteral penicillin therapy is indicated. The same applies to infected thrombophlebitis anywhere if there is reason to believe the offending organism is penicillin sensitive. In both conditions we would employ heparin in sufficient dosage (about 150 mg. per day) to maintain a clotting time of forty-five to sixty minutes, or dicoumarin to maintain a prothrombin time about 250 per cent of normal. Coagulation time determination must be done twice daily and prothrombin time determinations once daily if either of these agents is used.

*Gas Gangrene.* While the organisms responsible for gas gangrene are penicillin sensitive, disappointing results have followed the use of penicillin alone. Large doses (up to 400,000 units per twenty-four hours) combined with anti-serum have given favorable results.

*Compound Fractures.* Experience from the battle areas has emphasized the importance of early closure of the wound and local treatment along the lines laid down under "deep wounds." In addition parenteral administration of 100,000 units daily should be instituted promptly. What can happen when these principles

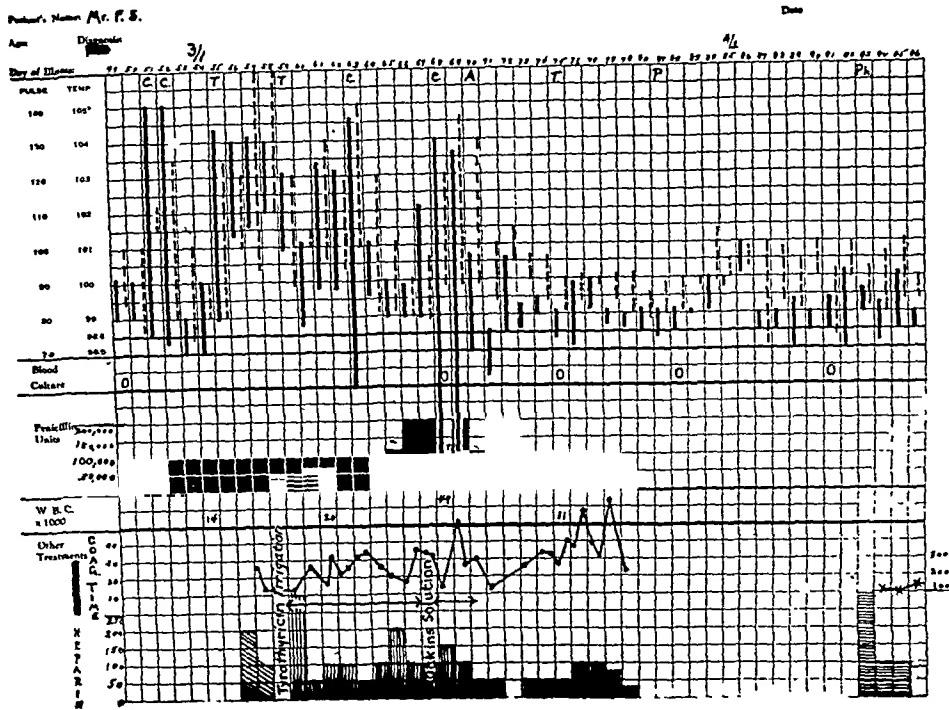
are not carried out as well as other points in penicillin therapy may be illustrated by the detailed consideration of a patient whose chart is shown (Fig. 1):



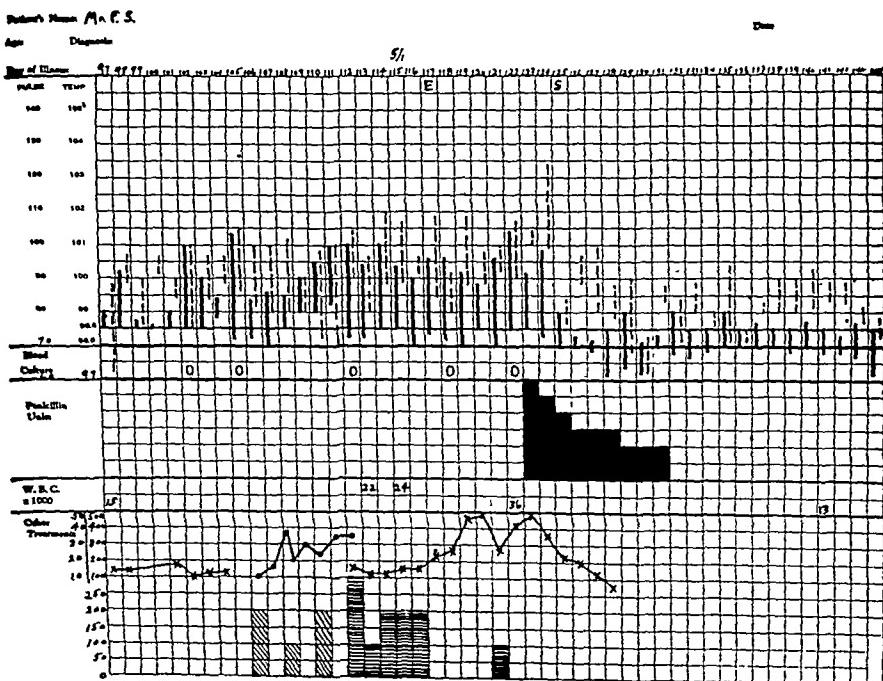
**FIG. 1.** Continuous, daily graph of patient with compound fracture referred to in text. A, solid line, daily temperature range; broken line, daily pulse range; diagonal hatching, sulfathiazole in Grams; w.i., wound irrigation with sulfathiazole; interrupted vertical lines, wound irrigation with penicillin; solid black squares, penicillin by continuous intravenous drip; s, incision and drainage; c, chill; t, blood transfusion. B, horizontal hatching in penicillin graph represents the only intramuscular and ministration. Diagonal hatching, intramuscular heparin in milligrams per twenty-four hours added to penicillin solution; horizontal hatching, dicumerol (lower graph) in milligrams per twenty-four hours; solid line with dots, coagulation time in minutes (Lee-White method); solid line with cross, prothrombin time in per cent of normal; a, amputation; p, pleurisy (possible pulmonary embolism); ph, evidence of thrombo-phlebitis. C, pulmonary embolism (E); drainage of abscess of left thigh (s); other symbols same as in B.

## CASE REPORT

The patient, a man of fifty-two, suffered a compound fracture of the left leg. When he entered the hospital on Dr. A. R. Metz' service about two weeks later local infection was already present. Evidence of systemic infection soon developed and an attempt to secure drainage was made. Cultures of the wound showed staphylococci. Blood cultures were sterile. Sulfathiazole was without effect. Again local incision for still better drainage did not improve the situation. Thrombophlebitis of the deep veins of



B



<sup>c</sup>  
the legend s  
y. 1871

FIG. 1. For descriptive legend see opposite page.

the thigh extending apparently to the lower iliac branches developed. Local penicillin therapy, first by instillation of crude filtrate, then by continuous drip of solution of the sodium salt into the drainage tubes was tried without apparent effect. Penicillin, by continuous intravenous drip in doses of 100,000 to 200,000 units per day, plus heparin, was then instituted. A favorable temperature response raised the hope that the situation was under control. This was of short duration, however, and the patient grew steadily worse even while penicillin was being administered. His aversion to losing his leg delayed amputation until his circulation began to show signs of failure and his condition was desperate.

At this point a rapid guillotine operation was performed by Dr. Metz. Examination of the leg revealed one reason for failure of previous local and systemic treatment, namely, an abscess along and under the Achilles tendon not touched by previous drainage and impossible to locate unless the leg had been systematically ribboned. Improvement was immediate and dramatic. The tremendously swollen thigh and flank receded at the rate of half inch a day. Then the improvement stopped and signs of fresh sepsis developed, accompanied by tenderness in the thigh and swelling. Further thrombophlebitis was diagnosed and heparin\* and dicoumarin\* administered, followed shortly by penicillin by continuous intravenous drip. No improvement resulted and signs of localized abscess in the thigh developed. Incision carried down to the level of the deep saphenous vein evacuated about 1,500 cc. of pus. Improvement was again sudden and dramatic and this time apparently permanent as he has had a normal temperature for three weeks, is gaining weight rapidly and has the appearance of a well man.

This experience emphasizes the following points: (1) The necessity for early local and systemic penicillin therapy in compound fractures. We realized later that we depended too much on local drainage and sulfonamides in the early weeks after admission. (2) The ineffectiveness of systemic penicillin in the presence of undrained abscesses. (3) The poor results from local penicillin therapy of multilocular infections. (4) The false favorable temperature response to penicillin when all other signs remain unfavorable. (5) The value of penicillin in promoting a dramatically favorable postoperative course in a desperately ill patient when indicated surgery is performed. (6) The fact that penicillin cannot replace indicated surgery. (7) The value of anticoagulants in the therapy of thrombophlebitis.

\* Most of the *heparin* and all of the dicoumarin (dicumerol) used in treating this patient was supplied through the courtesy of Abbott Laboratories. The intramuscular heparin used was obtained from Dr. Leo Loewe, Brooklyn, N. Y. and represents a special formula prepared for him by Hoffmann-LaRoche, Inc.

We believe that more extensive spread and embolism would likely have occurred without the use of these agents.

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## DISCUSSION

COL. ROBERT H. KENNEDY (Medical Corps): The ideas here expressed are the personal opinions of the discusser and it is to be considered that they represent in no way the opinions of other Army surgeons or the Medical Corps of the Army in general.

Penicillin treatment was commenced at the Percy Jones General Hospital in July, 1943. Up to the present time it has been used in over one hundred patients. We have found it apparently of great value in the small number of acute cases in which we have used it. Naturally, in a general hospital there are not many acute conditions in which it is to be advised, since these patients are more likely to appear in station hospitals. However, we have had occasion to treat one patient with erysipelas, one with acute sinusitis, one with acute mastoiditis, as well as several early wound infections. In all of these, in which a susceptible bacterium was found, it has seemed to us that excellent results were obtained. We have had no occasion to use it in acute blood stream infections.

For some time in our early experience it was used chiefly in the treatment of chronic osteomyelitis following gunshot wounds. Its use was continued for as long as seven and one-half weeks. None of us was particularly impressed with its value. It was possible to clear up streptococcus and staphylococcus in these wounds, but quite promptly proteus, coliform and

Bacillus pyocyaneus would appear. On stopping the drug, the streptococcus and staphylococcus were quite likely to re-appear. In these cases of chronic osteomyelitis, adequate complete surgery plays the most important rôle and penicillin can be considered only an adjuvant in the presence of foreign bodies or dead bone. We are unable even to state that in this condition penicillin is any more desirable than many other drugs that have been used in osteomyelitis.

It has been tried in several cases of empyema following gunshot wounds in which there were large cavities remaining, either with or without bronchial fistulas, both by local instillation and hypodermic administration and we have not been particularly impressed with its value.

In the past two months we have started using penicillin pre- and postoperatively in sequestrectomies and plastic revision of amputation stumps. Previously we had been using the sulfonamides for this purpose. There were reactions to the sulfonamides in a good many instances, which we believed to be due largely to the fact that most of these patients had had sulfonamides for one or more periods during their treatment previously. A poor appetite was frequent while sulfonamide was being administered, nausea fairly common and vomiting not rare. It is also too common to find red blood cells or gross blood in the urine. There were numerous instances in which the temperature rise was more than to be expected and in which it fell to normal when the sulfonamides were discontinued. For these reasons we changed to penicillin, with which in our entire experience there has been but little reaction. This consists almost entirely of an occasional case of urticaria and rarely a few red blood cells in the urine without symptoms. Nausea and vomiting have not occurred with penicillin in our experience. While using the sulfonamides it was rare to note any flare-up of cellulitis or other infection after sequestrectomy or revision of a stump. So far it has been just as rare to have this reaction following these operations with penicillin. Therefore, it is impossible to say that penicillin is any more effective for pre- and postoperative use in previously infected patients, but in our experience thus far, it has been at least as effective and without untoward symptoms. We usually give the drug for forty-eight to seventy-two hours preoperatively and continue postoperatively for five to seven days, discontinuing it then if general and local conditions do not seem to require its further use. It has been used pre- and post-operatively in two cases of lobectomy for bronchiectasis with rather marked infection. Each of these lobectomies healed well, but so have all the other lobectomies.

As time has gone on our dosage has in general become smaller. While we formerly used as much as 240,000 units a day, we now use in streptococcal cases 80,000 a day and in staphylococcal cases 120,000 to 160,000 a day. For intramuscular and intravenous use we make up the drug in 10,000

units per cc., and for local use in 250 to 1000 units per cc., usually 250. We have found that in an Army hospital intramuscular use is most satisfactory for continued administration, although in an acute case it is given both intramuscularly and intravenously for the first twenty-four to forty-eight hours in order to get in a large dose. There is no use in its administration unless it is to be given at least every three hours, day and night. This, of course, makes it administration difficult in anything but hospital practice. A few patients complain of burning sensation following intramuscular injection.

Quite recently we have had two patients whose clinical course suggested early gas bacillus infection. It is fair to state that gas bacilli were not proved in either case, although in one instance there were two considerable areas of necrotic muscle found on opening up the street wound which had been primarily sutured elsewhere. In each instance there was prompt thorough surgery accompanied by local and general use of penicillin and both cases responded promptly. We believe that we can express no opinion about the value of penicillin in gas infection.

It is unfortunate that the public has been brought to believe that this is such a miracle drug. It is our belief that it is a most valued addition to our armamentarium, but that proper complete surgery is more important than any drug.

WALLACE E. HERRELL (Rochester, Minn.): Penicillin therapy, I believe, may be recorded as one of the great advances in medicine, and for that reason the enthusiasm with which it has been received is unparalleled. This enthusiasm must, of course, in time be tempered as more and more is learned about the uses as well as the limitations of penicillin.

As I looked at the bottles which Dr. Priest showed a few moments ago in which penicillin was grown, I could not help but think of the transition which has occurred since Professor Florey visited at the Mayo Clinic in 1941, at which time we had these flat bottles all over the laboratory. As you may recall, it required 100 liters of the brew at that time to obtain enough penicillin to treat one patient for one day. What has happened since then is, of course, a great accomplishment and a great tribute to the scientific and industrial organizations of this country.

With regard to the local use of penicillin, I might remind you that the broth filtrate containing penicillin has proved satisfactory particularly when one does not have available the more purified penicillin. The broth filtrate is an entirely safe agent and can be obtained by simply filtering off the mold from the broth in which it is grown. This broth as well as the sodium or the calcium salt has been used with good results in the local treatment of bacterial infections. The sodium salt in the bulk is somewhat irritating. On the other hand, the calcium salt has not proved to be irrita-

tive. The calcium salt is also more stable as evidenced by the fact that my colleagues and I have kept calcium salt in the dry state for as long as six months at room temperature without finding any loss of potency. This, we believe, is of tremendous value particularly in connection with its use in theaters of war where refrigeration is not always available.

I was much interested and gratified to learn that Dr. Priest and his associates have found the continuous intravenous drip method of administering penicillin satisfactory. We have always believed that it was a satisfactory method if one is equipped to handle it. This much is certain, it is the only safe way by which a constant level of penicillin can be maintained in the blood. The burning sensation and local irritation associated with repeated intramuscular injections at times are somewhat troublesome. It has been apparent recently, however, that the degree of pigmentation of penicillin itself may affect this reaction somewhat. While the local or systemic reactions vary with different batches of penicillin, there is some evidence that the more deeply pigmented the penicillin is, as a rule, the more likely one is to encounter these side effects.

A word about the use of penicillin in the treatment of suppurative diseases of the joints and osteomyelitis which are, of course, of primary interest to this group. I concur completely in the opinion that penicillin is effective in the treatment of acute osteomyelitis. I might remind you, however, that the so-called masking effect which has been noted in the past in connection with sulfonamide therapy may occur with penicillin therapy in the treatment of acute hematogenous osteomyelitis. In one or two patients who were under treatment with penicillin for acute osteomyelitis, we have been badly fooled concerning the success of the treatment by the development of some quiet lesion which could be identified only by roentgenologic examination. In the treatment of chronic osteomyelitis penicillin alone is not the answer. Unless one is prepared to eradicate the focus and then combine penicillin therapy with other accepted forms of treatment, the results are not going to be satisfactory, at least this has been our experience at the clinic. I also might mention that the results in the treatment of osteomyelitis of the flat bones are in general better than the results obtained in the treatment of osteomyelitis of the long bones. We also have obtained satisfactory results in the treatment of subacute or spreading osteomyelitis of the flat bone owing to anaerobic and partially anaerobic streptococci.

I believe one of the discussants has already dealt with the question of phlebitis which occasionally may occur following the intravenous administration of penicillin and also the question of pyrogenic reactions. However, these pyrogenic reactions are not troublesome at present since practically all the penicillin available is pyrogen free. The only other toxic reaction of any significance which deserves mention at present is the urticaria and

dermatitis which may be encountered in no more than 2 or 3 per cent of patients. This skin reaction is bound to occur in certain individuals who are sensitive to molds and to mold products. If a severe dermatitis occurs during the course of penicillin therapy, one caution should be exercised: if one continues to force penicillin in the face of such a lesion, the possibility that a more extensive and probably exfoliative dermatitis may develop must be kept in mind.

WALTER S. PRIEST (closing): I was hoping Colonel Kennedy would mention the primary closure of wounds which has been done at some of the battle fronts. Having had no personal experience, I felt inadequate to discuss it. Reports have indicated good results. Extensive débridement is not done. Wounds are merely cleaned, dusted with penicillin and sutured. Sometimes a small stab wound is made and a rubber tube drain inserted through which penicillin is subsequently instilled. It might be a point worth investigating by those of you who see wounds of this type.

I am glad both Colonel Kennedy and Dr. Herrell deplored the tendency at present for penicillin to be used for anything and everything. We are seeing it used that way around the hospital, and it should not be done.

I observed one case of spreading osteomyelitis of the jaw, in which penicillin was ineffective, but I think in general the experience would coincide with that of Dr. Herrell.

## DEQUERVAIN'S DISEASE

STENOSING TENDOVAGINITIS AT THE RADIAL STYLOID

D. C. PATTERSON, M.D. AND ELWOOD K. JONES, M.D.  
BRIDGEPORT, CONNECTICUT

OME years ago Dr. George Hawley<sup>1</sup> called my attention to a painful condition of the wrist which has become known as DeQuervain's disease. It is a thickening of the tendon synovial sheath and the overlying annular ligament at the groove in the outer border of the lower end of the radius that transmits the tendons of the abductor longus pollicis and the extensor brevis pollicis muscles. This groove runs downward and forward and is covered by the annular ligament which forms a separate compartment for the two tendons. (Fig. 1.) The tendons are surrounded by a sheath that extends an inch above and an inch below the annular ligament. This sheath is filled with synovial fluid to facilitate the pulley-like action of the tendons. The tendon of the abductor pollicis is inserted into the base of the metacarpal bone of the thumb and the tendon of the extensor brevis pollicis into the first phalange. The cause of the thickening of the sheath and ligament is primarily mechanical irritation. Eschle<sup>2</sup> thought that over exertion caused increased friction, that the sheath became edematous and later thickened from fibrous tissue formation. In early cases on opening the sheath a small amount of synovial fluid is found; in advanced cases we have found it dry. The tendons rarely show any change in appearance though in some cases a constriction has been noticed from pressure. Similar changes have been observed in other tendons where they are angulated within a tendon sheath such as those causing "snapping thumb" and trigger finger.

While DeQuervain<sup>3</sup> has been credited with first describing this condition in 1895, there appears in Gray's Anatomy, 13th edition published in 1893, the following note: "The tendons of the extensor muscles of the thumb are liable to become strained and the sheath inflamed, after excessive exercise, producing a sausage-shaped swelling along the course of the tendon, and giving rise to a crackling sensation to the finger. As it was often caused by such movements as wringing clothes, it was known as "Washerwoman's Sprain." I believe this was the same condition that we are discussing.

As it was about the turn of the century when the mechanical wringer was introduced, one might surmise that its use led to a lowered incidence of the disease, only to have a renewed frequency

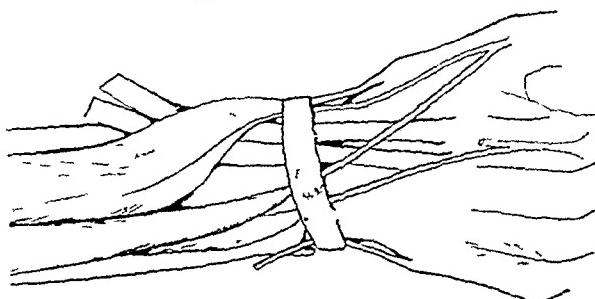


FIG. 1.

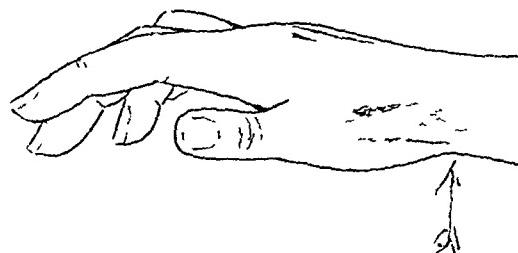


FIG. 2.

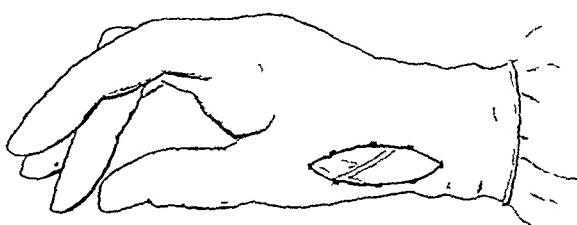


FIG. 3.

FIG. 1. Shows tendons of short extensors of thumb passing under annular ligament at radial styloid.

FIG. 2. Snuff box, shows short extensors of thumb forming lower border.

FIG. 3. Shows method of protecting field of operation.  
Opening in rubber glove is over radial styloid.

as women became actively engaged in factory work which required excessive use of the thumbs.

Dr. Morrison and Dr. Cotton<sup>4</sup> have pointed out that this condition has received but scant attention in text books or surgical literature and this is true. I believe that the disease is not generally

recognized and that quite a number of cases are under treatment for sprain, arthritis, neuritis, osteitis, periostitis or tenosynovitis. From conversation with surgical friends I find that very few of



FIG. 4. Microphotograph of section removed at operation.

them are familiar with the condition, though they all were sure they had seen such cases but had failed to recognize them. The condition is not uncommon, for at one time in the Summer of 1942 we had five patients under treatment. When one has it in mind the diagnosis is easy, and I know of no condition in which the results of treatment are more satisfactory both to the patient and the surgeon.

The etiological factor is undoubtedly trauma, and this is generally of a chronic nature. In most of our cases the patients were engaged in occupations that required pressure by the thumb while it was in a partially abducted position, such as work on a grinding or buffing machine. In one of our cases the patient, a woman, was employed putting tight fitting rubber rings over a piece of pipe. To do this she would press firmly on the ring with both thumbs. One day in order to complete a rush order she performed this act five hundred times. That night she had severe pain in both thumbs. We saw her a month later when her symptoms were still severe in spite of the fact that she had been receiving local treatment since the injury. Another patient pressed clothes with a heavy iron. Dr. Frederick Cotton<sup>4</sup> reported a case occurring as a result of fly casting with a light rod.

Since a previous report in 1935 I have seen several cases in which the patients stated that their symptoms followed a blow on the wrist or a fall on the hand. In some cases I think the blow or fall was coincidental or aggravated a pre-existing condition, because the work of these patients was such as to favor tenosynovitis. I am not convinced that this condition can result from a single trauma, as the condition definitely suggests a chronic disease.

There is a great preponderance of the disease in females. Finkelstein<sup>5</sup> reported only four male patients in twenty-four cases; and Schneider<sup>6</sup> fourteen males in 135 cases that he collected. In a series of thirty-two cases we had eight males and twenty-four females.

The symptoms and signs of DeQuervain's disease are quite definite and the similarity in all cases is very striking. As a rule the onset is gradual. The patient will complain of pain in the wrist of several weeks' duration and when questioned will locate the pain over the radial styloid. They also refer to pain running up the arm and downward into the thumb. Pain is aggravated on abduction of the thumb, or ulnar adduction of the hand. This can be demonstrated by flexing the thumb in the palm of the hand, and with the fingers closed over it making sharp ulnar adduction. The pain gradually increases with use of the thumb. Later weakness of the hand develops and patients complain that they drop even small objects. Considerable disability usually results. Objectively, there may be slight swelling over the affected part. There is marked tenderness over the styloid process. (Fig. 2.) Abduction of the thumb is restricted and forced adduction is painful. Crepitus can be felt only rarely.

There have been some cases of recovery reported under non-operative treatment, but the time required to get relief was from four months to two years. I have one patient who refused an operation but her work had to be changed, and even two years after this was done she showed signs of the disease. Another patient who had been treated with plaster immobilization for six months without benefit had quick relief after operation. A few years later she developed the condition in the other wrist and requested immediate operation. I should think the recurrence rate after conservative treatment would be great and immobilization with a plaster cast on the hand is a discomfort in itself.

The operative treatment is so simple, giving early relief of pain and a period of disability so short, that it should be the treatment

of choice in all cases. This is well illustrated by two patients I examined recently. Both worked at the same job. Mrs. G., aged fifty-one developed bilateral DeQuervain's disease in October, 1940. She refused operative treatment and stopped her work which had required a twisting motion of thumb and wrist. She had some relief of pain from adhesive strapping of the thumb. She remained out of work for six weeks, and when she returned her job had to be changed. For over two years she showed signs of the disease. When seen last month all symptoms and signs were gone, but she would not go back to her previous occupation. Mrs. H., aged fifty-three had symptoms for about six weeks. She had constant pain and complained, "I can't hold anything." She was operated upon January 22, 1944, under local anesthesia, returned to her usual work on February 1st, and when seen last month said she had had no discomfort since doing so. Her period of disability was exactly one week.

The operation is conveniently performed under local anesthesia. After proper preparation of the hand and forearm, a sterile rubber glove is put on the hand and a small opening made through it over the operative site. (Fig. 3.) We have found this a very satisfactory protection in operations on the hand and fingers. A tourniquet is applied and a short incision made over the radial styloid. Care should be taken to avoid a small branch of the radial nerve. The carpal ligament and tendon sheath are exposed. In fully developed cases they have somewhat the appearance of a miniature infantile pyloric hypertrophy. The thickened tissue over the styloid groove is incised; it generally gapes, exposing the tendons. Nothing further need be done to the sheath. The skin incision is then closed in two layers, and a firm bandage applied. No splinting is necessary, and the thumb is not immobilized. Free motion of the thumb is permitted in two days' time, and full use is generally possible at the end of two weeks. We have had no case in which relief was not obtained.

Finkelstein recorded his microscopical findings as follows: "In mild cases the synovial membrane is thickened except at the point of constriction where it is thin or absent. The loose connective tissue layer is considerably thickened and vascularized. The ligamentous layer is slightly thickened and not vascularized. Only rarely is there a line of demarkation between the loose connective tissue layer and the ligamentous layer. In severe cases the synovial

layer is completely destroyed; the loose connective tissue layer is compressed and thinned out; while the ligamentous layer is markedly thickened and undergoes hyaline and cartilaginous transformation. There is also marked thickening of the walls of blood vessels, and cellular infiltration of the tissues, numerous lymphocytes being present. Between these two types are many gradations." All of our sections have shown similar changes. (Fig. 4.)

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#### DISCUSSION

GORDON M. MORRISON (Boston, Mass.): Dr. Patterson has left little to be said. He has done a good job on the subject. I like a dry field in order to identify the sensory branch of the radial nerve to the thumb so that it may be retracted and not injured.

As Dr. Patterson has said, removing the cartilage-like housing on the tendons is simple, permitting the tendons to move freely right away. Then suture the skin, start motion within forty-eight hours, and the results are excellent.

# RECONDITIONING FOR THE WAR WOUNDED

## THE UNITED STATES ARMY SERVICE FORCES' PROGRAM

COLONEL AUGUSTUS THORNDIKE

MEDICAL CORPS, ARMY OF THE UNITED STATES

UNTIL the infamous attack on Pearl Harbor it had been the policy of the Medical Department routinely to grant convalescent furloughs to soldiers hospitalized for any great length of time. However, upon the outbreak of hostilities it became increasingly discernible that the convalescent furlough was ineffective and impractical as a means of promoting rapid convalescence of disabled soldiers during wartime. Far too many patients returning from convalescent furloughs were found to be in inferior condition to that with which they departed. Once at home the soldier, and especially the experienced combat soldier, was usually caught up in a whirl of strength-depleting social activities provided by well intentioned friends and relatives anxious to entertain or amuse the soldier on furlough.

The physical demands made on the soldier by participation in the intensified training program, or engaging in active combat, made it imperative that the convalescing patient not be returned to a duty status until he had completely regained his lost stamina. The urgency of the military situation, on the other hand, necessitated a reduction in the time absent from duty, because of illness, consistent with the welfare of the soldier. The Reconditioning Program was developed as a solution to this reduction in the non-effective rate of field units.

This program provides for the soldier recuperating from wounds, illness or injury, a regimen of activities designed to hasten his return to duty in that high state of physical and mental health recognized as an indispensable precursor to effective participation in any intensive military training. It is also being used with gratifying results as a proving ground, where soldier patients disqualified for full military duty are evaluated under working conditions for the purpose of determining assignments commensurate with the disability.

### BED PATIENT

The reconditioning regimen for the bed patient, who has entered the convalescent stage, consists of a program comprised of three

integral parts: First, physical reconditioning composed of short daily periods of light bed exercises of various types designed to allay muscular atony and atrophy in those parts of the body not diseased or injured; second, educational reconditioning composed of an organized program of lectures, group discussions on topics of general interest, study of approved credit courses in the United States Armed Forces Institute, reading or observing of current items in papers, magazines or radio or motion pictures in the ward, intended to promote that natural instinct of ever seeking after the truth and the desire to learn more of the reasons why we fight; and third, occupational therapy consisting of light purposeful tasks, creative art or handicraft, such as making medicine swabs, folding dressings, fabricating camouflage nets, helmet nets, leather working and wood carving. Objectively directed in bed occupations have been found of considerable assistance in the restoration of function to injured or diseased parts of the body. Perhaps in the recent past so-called "bed rest" has provided too many periods of physical and mental idleness. This program is aimed to avert such idleness.

#### AMBULATORY PATIENT

The physical reconditioning prescribed for the ambulatory ward patient is more strenuous and includes calisthenics, remedial exercises, light gymnastics and mild games such as croquet, quoits and horseshoes. These exercises have as their purpose the gradual restoration of normal physical vigor, while the patient still requires ward care.

The educational program for the ambulatory ward patient is designed to develop within the patient the desire for a speedy return to health, while increasing his general knowledge by providing lectures and conferences on various educational subjects. Through encouraging the patient to study United States Armed Forces Institute correspondence courses with a view to completing credits for his high school diploma or college degree, a profitable experience is offered. At this time 115,000 soldiers are enrolled in these courses (9,000 represent fourth year high school students). A large percentage of this student body is in overseas stations. Time in hospital has been found to be an appropriate time to start such an activity.

Ambulatory patients engage in more strenuous types of occupational therapy, such as cabinet making, weaving, fly tying, printing, pottery making, etc., all such activities carried on in a

shop. They are required to make their own beds, assist less agile patients in self-care, and are assigned for short periods daily to various departments of the hospital to assist Medical Department personnel.

#### ADVANCED RECONDITIONING SECTION

When ward or clinic treatment is no longer required, soldiers, whose illness or hospitalization has been so brief as not to permit of any appreciable loss in condition, are returned directly to duty, while all others who may be expected to return to duty, are admitted to the Advanced Reconditioning Section for further physical training. The greater part of this training is devoted to physical reconditioning activities co-ordinated with a few hours per day of intensive military training.

Since the restoration of a patient to full health progresses much more rapidly when the convalescent period takes place outside of the hospital, Advanced Reconditioning Sections simulate the average training company as closely as possible. To this end patients are housed in barracks detached from the hospital, clothed in regular duty uniforms, granted all of the privileges normally afforded the soldier on a full duty status, subjected to the same rules of discipline, and are referred to as "trainees."

The physical training program provided for the trainees includes gymnastics, combatives, obstacle course running, games, calisthenics, swimming and marches up to fifteen miles.

Educational reconditioning for the trainee is limited to two hours per day of instruction in subjects which actually constitute a refresher course in basic military training. Emphasis is placed on map reading, scouting and patrolling, weapons and their uses, first aid, and field sanitation. At certain station hospitals where the troops hospitalized are predominantly of one branch, such as at a Signal Corps Replacement Training Center, the patient trainee is provided instruction similar to that which he would receive in his company and thereby loses no training time while hospitalized.

The occupational therapy prescribed for the trainee consists of useful activities such as painting, plumbing, gardening, carpentry and the like—work therapy for the benefit of the hospital.

Throughout the entire program physical reconditioning activities are prescribed by medical officers and executed under the guidance of trained instructors. The intensity and duration of exercises

are increased in direct ratio with the progress made by the patient, but under the guidance of the medical officer.

Patients unfit for full military service are frequently assigned to the Advanced Reconditioning Section where they are studied under working conditions with a view to determining a duty to which they might be reassigned, the performance of which would involve activity commensurate with their remaining capacities. If this disability precludes further military service, he is required to attend a brief course of instruction in the responsibilities which one would be expected to assume as a civilian. Manpower is being salvaged for both the Army and War Industry by this procedure.

In an appraisal of the progress made thus far, manifest results stand as incontrovertible evidence of considerable success attained. The magnitude of the task which lies ahead constitutes an ever present warning that, if one is to succeed, there can be no relaxation of effort.

We are now engaged in the actual procurement of qualified personnel, the assignment of officers and enlisted men who are at present performing other duties within the Army. Four courses have been established at two schools for the purpose of providing technical instruction for both officers and enlisted men to qualify them as physical and educational reconditioning instructors. The dearth of scientific publications pertaining to the reconditioning field has forced us to prepare a complete manual describing approved reconditioning practices and technics. A motion picture is also being produced for the purpose of educating duty personnel in the technical aspects of reconditioning. The reconditioning program is now operating in all Army Service Force Hospitals in the continental United States, as well as in each overseas theater.

The establishment of a reconditioning service in Army Service Force hospitals has been authorized with a Chief of Service at the same organizational level as the Medical and Surgical Services. The Chief of this service is responsible to the Commanding Officer and controls all phases of this program with a very close liaison with the professional staff of the Medical and Surgical Services. No patient can enter the program without the approval of the ward officer or chief of section. Approximately 70 per cent of the patient population of each hospital is participating daily in this program.

It is an uncompromising resolve, however, that every soldier returned to duty from an Army Service Forces hospital shall have

restored to him the strength, endurance, agility and ruggedness prerequisite to effective training or combat. The practical significance of battle casualties returning to the front lines in their unit with such an attitude of mind, can hardly be exaggerated.

It is a confident hope that as the scroll of destiny unfurls, in the post-war era we shall find that from the pioneering of the Medical Department of the United States Army in this relatively unexplored field of reconditioning, there shall have emanated a basis for the establishment of scientifically sound procedures for the accomplishment and acceleration of convalescence. These three phases of the balanced program, physical, educational and occupational reconditioning, are essential to produce results. Bed patients, ambulatory ward patients and trainees all must experience a balanced program—a progressive program in all phases and tasks.

Results at this time have proved that the hospital stay and the readmission rate have been reduced, and that the soldier patient is returned to duty or to civilian life better conditioned, better educated, informed and oriented—a better soldier or veteran.

#### DISCUSSION

COL. DON G. HILDRUP (Medical Corps): Colonel Thorndike has discussed the purpose and outlined the scope of the reconditioning program as it is being carried out in Army Service Forces hospitals. The value of the program is largely dependent upon the active and enthusiastic participation of every member of the hospital staff. It is sometimes difficult to sell new ideas to people who have for years followed a certain line of thinking. Therefore, to make the program successful, all personnel having to do with it must be well indoctrinated in its principle and sold on the idea.

The Army is at present confronted with two very vital problems concerning hospitalization: First to keep specialized beds available, and second to prevent physical and mental deterioration among patients. In the early days of the war and during peace times, personnel often objected to being sent to Army General Hospitals because the stay was usually prolonged and it was difficult to obtain a discharge to duty. With enlargement of the Army and the scarcity of medical officers to staff these hospitals, the necessity for decreasing hospital days became imperative. Further, it was found that the longer a patient remained in the hospital the less was his desire to return to active military duty. In other words, morale decreased as the days in the hospital increased. The old adage that "idleness was the Devil's workshop" was never better illustrated. Reconditioning, therefore, has a three-fold purpose: First, to expedite convalescence and the return of full physical powers; second, to occupy the idle hours of the

patient both from a mental and physical standpoint; third, to improve morale, morale being defined as that intangible mental attitude which causes an individual to be satisfied with his position and eager to do his job quickly and thoroughly.

It is too early to evaluate the accomplishments of this program finally. It is clearly apparent, however, that desirable objectives are being attained and that convalescence in the average hospital case is reduced approximately 30 per cent. Soldiers with debilitating diseases and injuries are being rehabilitated in a shorter time than formerly and returned to their organizations in physical condition which permits them to slip into service routine without undue fatigue or relapse. They return with more enthusiasm than formerly, and the mental attitude of the convalescent is improved. In the Sixth Service Command there are 4 General Hospitals having in excess of 6,000 beds, as well as several large Station Hospitals in excess of 1,000 beds each. The reconditioning program is being carried out in all of these. We are now establishing a Convalescent Camp in Michigan, to which all Class I and II patients will be sent for intensive reconditioning. By this program the percentage of ambulant patients in our hospitals, which now averages 70 per cent of all patients, will be reduced to approximately 30 per cent, thus increasing our available beds by approximately 3,000. When this plan is applied to all the larger Army hospitals in continental United States, it will increase the bed capacity in excess of 100,000 beds by the elimination of ambulant convalescents. It is expected that these beds will shortly be required for casualties resulting from the present military operation in Europe.

An Army medical policy which is fixed and unalterable is to give the hospitalized soldier the best medical attention that the country affords. By means of frequent and thorough inspection by competent professional consultants it is possible for the Surgeon of a given command to maintain in responsible positions only those medical officers whose capabilities and work measure up to required standards. Thus with professional care of the highest order, supervised reconditioning will not only accomplish its end as planned but will decrease the routine load of the hospital medical officer. It will effect an economy of professional talent which at the present time is the greatest problem of the Medical Department.

Lt. Col. FRANCIS M. MCKEEVER (Medical Corps): Before discussing the Army's program for rehabilitation of the amputee, I would like to sketch briefly the situation which the Army today is faced with in caring for patients who have suffered amputations. This problem differs in many respects from that of civilian life, not only as to magnitude but as to character. Needless to say, the number of amputees is greatly increased. In addition to this the patients are of a different age group. They are men for the most part in their twenties or early thirties who in the future must

earn a living. They are, in large percentage, men who followed arduous occupations requiring strength and agility prior to their Army service.

In civilian life most amputations are done in elderly people because of



FIG. 1. Type of artificial leg used.

vascular disease or because of malignant tumors. Only a relatively few are brought about by trauma. Consequently, closed amputations are performed and the operation is completed at one sitting. Six to eight weeks after operation the patient is ready for a prosthesis. On the other hand, the amputations resulting from combat are all the result of trauma and are all infected or potentially infected. The initial operation is often done under unfavorable circumstances. The patients must be sent through a chain of evacuation away from the site of activity. They not only leave the care of the surgeon, who did the operation, but pass through the hands of many different surgeons during the crucial period of postoperative care when bacterial invasion may be lethal.

Because of these facts, closed amputations are not done on battle casualties requiring the removal of an extremity. All amputations done at the front are open or guillotine amputations and it is understood that a



FIG. 2. Patient walking with crutches.

secondary operation consisting of a reamputation or a plastic closure will be necessary at a later date to produce the final stump. This policy is absolutely necessary in war to prevent useless loss of life and useless sacrifice of bone length from sepsis.

To afford proper care and proper rehabilitation to the amputee certain Army General Hospitals in the Zone of the Interior have been designated as Amputation Centers. All patients who have suffered amputations in the Army are sent to the Amputation Center nearest their home locality. They cannot go to the hospital nearest their home but must go to the hospital organized as an Amputation Center, which is nearest their home.

The Amputation Center brings together the following features: (1) A surgical staff experienced in amputations; (2) an artificial limb shop; (3) physical therapy; and (4) occupational therapy. The following policy has been adopted relative to the discharge of a patient from an Amputation Center: First, all patients must be fitted with a prosthesis. Second, the patient with a lower leg amputation or an end bearing thigh amputation must be able to walk well on level ground without a cane. A patient with a mid-thigh or high thigh amputation must be able to walk well on level

ground with no more aid than a cane. Few patients with the exception of those having the very short thigh stumps use a cane. Third, an arm amputee must be supplied with both an artificial hand and the utility hook and



FIG. 3. Patient walking in ramp

must be able to write, to eat, to dress himself, and to keep himself clean without help. When these objectives have been accomplished, the patient may be returned to civilian life or if he desires, an attempt will be made to find a place for him in the Army.

In order to accomplish the above end the surgeon must first of all do what surgery is necessary to produce a good stump. As practically 100 per cent of the patients have previously had a guillotine amputation at the lowest possible level, and since many of the extremities have suffered multiple wounds, the surgeon may be greatly compromised from a cosmetic viewpoint. It may be impossible to place the scar at the optimum point or iron out all furrows on the stump without sacrificing uselessly good bone length. Either a reamputation at the site of election or a plastic

closure is done. For example, a leg which had previously had an open amputation through the knee joint would be reamputated at the supracondylar level; a very short thigh stump would have a plastic closure with

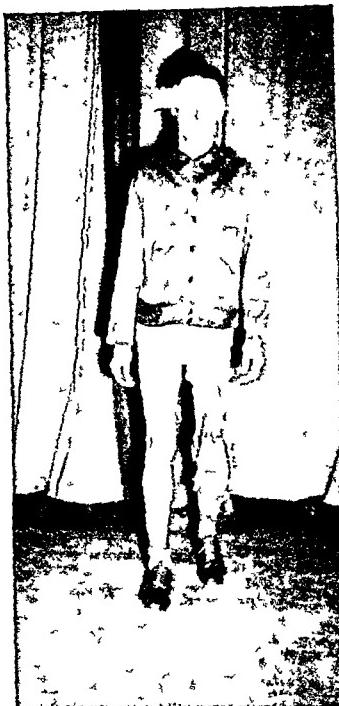


FIG. 4. Patient walking without any support.

as little sacrifice of bone as might be necessary to permit of a good closure of the skin.

As soon after surgical closure as the stump will permit, bandaging with elastic bandages is started to promote shrinkage of the tissues. This treatment is usually tolerated about the tenth day after operation. At about twenty-one days it is possible to further hasten the shrinkage of the stump and increase the circulation of the tissues by massage started lightly and increased in intensity.

At this time it is usually possible to institute exercises to develop the muscles necessary for a good gait and to stretch out any contractures which may have developed. It is not uncommon for the thigh amputee to have a hip flexion contracture, for the below knee amputee to have a hamstring contracture, and for the arm amputee to have a pectoral contracture. For good walking the thigh amputee needs strong hip extensors and strong hip adductors, otherwise the gait will be lurching. The below knee amputee needs a good quadriceps, otherwise, he cannot control the knee and the

prosthesis may let him down. It is obvious that no arm prosthesis can be worked effectively with a pectoral contracture and that a strong deltoid muscle must be developed. The bandaging, massage, and exercise all hasten the shrinkage of the stump.

When the initial edema and swelling incident to the operation have subsided, and when the incision is well healed, the patient is fitted with a prosthesis. This can usually be effected six to ten weeks after the final operative procedure. The prosthesis with which the patient is fitted is not a peg leg or pylon, but is an artificial extremity containing joints and is similar in basic construction to all artificial extremities. It is made, however, of a fiber material which can be adjusted frequently in the leg shop to compensate for the rapid shrinkage which follows active use of an extremity. This leg is fitted individually to each patient by taking a plaster mold of the stump and making an individual socket for each amputee.

After being fitted with the leg the patient is then taught to walk. He is taught first with crutches as the stump in the early stages may be sensitive. He is next given individual walking instruction and exercise in a ramp, being drilled in the proper muscles to use, the proper steps to take, and is shown the common mistakes to avoid, such as looking at his feet, walking with a wide base, etc. When a good gait has been mastered and the patient handles himself well without any support, he is graduated to a class, which in addition to walking drill, also includes calisthenics aimed at co-ordination. During all this time active resistive exercises to develop the important muscle groups are carried out on each patient each day.

The upper extremity amputee is sent to occupational therapy in addition to physical therapy. The occupational therapist trains the patient in activities requiring the use of both hands. Each arm amputee is taught the use of the hook and of the artificial hand for eating, for lifting, for dressing, and other more advanced and complicated activities. If the amputee has been a right-handed individual and lost his right arm, he is taught writing with the hook and artificial hand. Most patients who have lost their right arm, however, have already acquired considerable skill in writing with the left hand by the time they are ready for this program. In the weeks which elapse during transport of a patient from the Antipodes or Mediterranean, the vast majority have acquired the ability to write very legibly.

In addition to the above outlined procedures there is also a dancing class held daily in which ballroom dancing is taught. This is optional. It is much enjoyed by the men and does a great deal toward restoring self assurance. There is also an automobile available, and an instructor in driving, himself an amputee, who teaches the men to operate a motor vehicle with their prosthesis.

For any individual whose mental adjustment to the loss of his extremity is inadequate, the attention of a trained psychiatrist is available. In our

experiences his services have been but rarely necessary. The overwhelming majority of these men meet their problem with a smile and when they see the progress of those about them, buckle down to hard work. It can be said without reservation that the morale of the amputee is the highest of any group of hospital patients.

Concomitantly with the above program the patient has the opportunity for orientation courses, has access to a library, which through affiliations will obtain for him practically any type of text or literature that he may desire. The amputee is also given the opportunity of taking additional work in occupational therapy where leather work, crafts, printing, power tools, draughting outfits, painting equipment, sign making apparatus, and various other facilities are available.

When the patient and prosthesis are well adjusted to each other and the individual has no discomfort from its use, he is given a lengthy furlough if desired. In this way each individual gets an opportunity to meet his previous environment. On return from this furlough the stump is usually further shrunken and appropriate adjustments are made in the bucket of the prosthesis. If the tissues of the stump have withstood the increased activity of the furlough well, the amputee is given the opportunity of returning to some suitable duty in the Army or of returning to civilian life.

On the patient's return to civilian life his further rehabilitation is taken up by the Veterans' Facility in order that the full meaning of the word rehabilitation, at least from the economic angle, may be accomplished. Prior to discharge from the Amputation Center the patient is interviewed by a representative of the Veterans' Facility and apprised of further educational facilities and compensation privileges. He is also given a booklet which contains instructions in the care of his stump and his prosthesis.

Men who prior to Army service have followed sedentary or mental occupations are able immediately to return to a wage earning status. Men whose previous work has been arduous and laborious will have to be trained in less strenuous vocations. Many youngsters have not as yet engaged in or settled themselves in any type of work. Some of these will go to vocational school, others will take extended training in schools of higher education. Direction in these opportunities is a function of the Veterans' Facility and obviously not a program that can be carried out in a hospital.

The Amputation Center of the Army General Hospital strives to carry rehabilitation of the amputee to the point where he has (1) the best possible stump that surgery can offer, (2) a satisfactory, comfortable prosthesis, (3) skill in the use of this prosthesis, (4) the capacity to meet the routine demands of everyday life, (5) a healthy outlook to the future, (6) a desire

to overcome his handicap, and (7) information as to where and how he may obtain help in becoming an independent economic unit.

HARRY MOCK (Chicago, Ill.): I talked with Colonel Hildrup just before this meeting, again begging him to find a place for me in this war. Colonel, in spite of what you say about my age, in spite of what they have told me in Washington, I am still in this war! Charlie was one of my boys. I cannot tell you how thrilled I was when I saw Charlie in the movie. He depicts the spirit of rehabilitation which we fought and bled for in the Surgeon General's office and throughout the Army in the last war.

I daresay, Colonel Thorndike, that you will have the same problems we were confronted with in the last war: a sort of half-hearted acceptance of your program on the part of the medical officers; a reaction against the sentimental ideals embodied in rehabilitation and usually expressed by the more hard-boiled officers as, "O hell, we're fighting a war!" This lack of enthusiastic co-operation is the hardest thing to overcome in such a program, whether you call it "rehabilitation" or "reconditioning."

Twenty-six years ago, almost to the day, I talked on this subject before the open forum of The American Medical Association here in Chicago. The Auditorium Theater was crowded. President Wilson's pledge to the disabled soldiers that they would not languish in old soldiers' homes, but rather they would be rehabilitated and made fit for work once more—useful economic units of society in spite of their disabilities. Our program of physical reconstruction and rehabilitation was outlined to the audience. It went over big with the civilians. It was accepted half-heartedly by the Medical Department of the Army.

We went to work on the plan and had to work faster in the last war than you have had to work in this war, because our time was shorter. Within one year after the United States entered the last war we had a fully developed program of rehabilitation working. We found that it had to start in the hospitals with the soldiers when they were first wounded; the spirit of rehabilitation had to be inculcated into those men early, the spirit of rehabilitation as depicted by Charlie.

We found that to get the best results the men must get away from the hospital as soon as possible, and carry on in convalescent centers. As a result, we soon had nineteen convalescent centers scattered over this country within the year, and in those nineteen convalescent centers we were doing the things which you have depicted as your program, Colonel Thorndike.

The occupational therapy there consisted largely of good, sound, manly mechanical work: automobile repair, not radio then but wireless work, typing, telegraphy. We placed 106 telegraphers with Western Union before the Armistice was signed.

Reconditioning, we called it then "redevelopment," also had its place in our program. Every cantonment had its redevelopment center where the

soldiers, not truly hospital cases but still not quite fit for regular service, were assigned for reconditioning. In these centers were the asthenic individuals, the flat-feet and other foot problems, the low back pains (because then the herniated disc was unknown), and similar conditions. Many of the regular Army officers, and even many of the Reserve Corps resented these innovations. A foul trick almost disrupted the usefulness of these redevelopment centers. Some high official secured a general order, placing all of the venereal cases in the redevelopment centers, and the morale of many of these centers immediately sank to zero. In spite of this, the idea was sound, and your present reconditioning program will prove its soundness.

Limited Service was born in the last war. I still have the original memorandum presented to the Surgeon General through Colonel Frank Billings, pointing out that "physical qualifications plus occupational qualifications should equal the job;" that I had an able-bodied surgeon as a stenographer who was crazy to go overseas and fight and who could have been replaced by a handicapped young lawyer from Philadelphia, who was a good stenographer and anxious to be in uniform; that tens of thousands of slightly handicapped individuals had been rejected in the draft examinations, who could be classified for limited service, thus freeing many an able-bodied soldier for overseas front line duty. The plan was accepted by the general staff. A camp was established in Syracuse, New York, and 50,000 rejectees from the draft were ordered to Syracuse. Here medical officers worked in conjunction with personnel officers. These men were re-examined and were classified as follows:

Class A, fit for overseas duty; Class B, fit for overseas limited duty back of the line; Class C, fit for limited duty in this country; Class D, unfit for any type of duty. B and C Class men were then examined by the personnel officers and were assigned to duty according to their qualifications. Three months before the Armistice we had sent 10,000 B Class men overseas, and 30,000 C Class men had replaced able-bodied soldiers in this country.

The day of the false Armistice I was in a meeting with Colonel Love, of the Surgeon General's office, the Assistant Secretary of the Treasury, who then represented the Veteran's Bureau, and two personnel men from the general staff. We were rounding out a plan for retaining illiterates in the Army until they could read and write. Already, in the redevelopment centers and in the convalescent centers, schools for the illiterates had been established, but the true Armistice ended this program. Many in those days frowned upon these innovations in the making of soldiers. Let us hope that this humanitarian viewpoint is more acceptable in the present Army.

In June, of 1942, I went to the Surgeon General enthused with this memory of the work Colonel Billings and my other associates had done in the other war. Of course, some plan of rehabilitation must be contemplated.

The Surgeon General turned me over to a colonel, the colonel turned me over to a major, and the major to a captain, and each time I heard the same story, "We are not going to do that stuff in this war; such work as this will be turned over to the Red Cross."

The present Surgeon General, General Kirk, has been in charge less than a year. I take my hat off to him because he has seen the vision and has established in this country, in this military Army of ours, a rehabilitation program that is equal and is going to be far better because of additional time, than the one we had in the last war. It is hoped that every medical officer in the Army and in the Navy will get behind such a program whole-heartedly.

Rehabilitation is a spirit. It is hard to define. You just felt it when you were thrilled by watching Charlie in the movie. This soldier of the last war, who lost both his arms, is one of the outstanding examples of rehabilitation. Enthused over my work with the disabled soldiers, in the Spring of 1918, I felt that I had taught this spirit of rehabilitation. It came over me in the middle of the night and I got up and wrote the Creed of the Disabled:

Once more to be useful;  
to see pity in the eyes of my friends  
replaced by commendation;  
to work, produce, provide;  
seeking no favors and given none;  
a man among men in spite of this physical handicap.

Colonel Thorndike, your presentation of the present plans for the disabled soldiers indicates that you have grasped the spirit of rehabilitation. As an old soldier fighting in this same department in World War I, I wish you the greatest success in your program.

HENRY C. MARBLE (Boston, Mass.): The question that comes to some of us now is that we must have more data to go beyond this. These boys discharged from the Army with one arm or one leg are physically handicapped. They go looking for a job. In theory the job is open, but in practice the door is often closed. The man who has the key to the door is the president of the corporation, and he is the one who shall say whether or not that door shall be opened.

He often calls upon his friend, the man with whom he plays golf, or his family doctor, for advice. His family doctor, his friend, you and I, may be of a great deal of value to him in advising him to open that door so these men can go back to work.

With this in mind I tried to find out if I could what the hazard is of these men. Are they a hazard? We all say no, they are not a hazard, but we really do not know.

After a good deal of research I have found two institutions, one in Pennsylvania in which they employ none but blind people, and another institution in New Jersey in which they make a practice of employing none but cripples.

Where did I get the facts? I went to the insurance company that insured the crippled people and I said, "What is the experience?" I went to the company that insured the blind people and said to them, "What is your experience?"

For a basis of comparison, let me tell you that in an ordinary machine shop employing normal persons they pay in compensation insurance approximately \$1 per \$100 payroll. Employing normal persons, doing light machine work, they pay \$1 per \$100 of payroll. The institution for crippled men (I remember these figures) in 1938 paid \$1.40 per \$100 payroll and they had nothing but cripples. That was in 1938. In 1939, they paid \$1.25, and the last figures I could get were for 1943 and showed that they were paying approximately 70 cents per \$100 of payroll.

In other words, there is a machine shop in New Jersey which employs none but cripples, who in 1943 have 30 cents credit over a machine shop employing normal people.

I hand that on to you so you may have it to answer the gentleman who comes to you and says, "Shall I open the door?" The experience of the blind factory in Philadelphia is comparable.

In Philadelphia they have two parts, one who makes furniture and uses machinery for making furniture, and the other that does weaving. I have never visited the institution, but I am going to. The highest experience that those blind people have had in the last ten years has been about \$1.25 per \$100 of payroll, and every man in the institution is blind.

COL. AUGUSTUS THORNDIKE (closing): I wish to thank these discussers. They have given me a beautiful creed to work under now. I shall use that, Dr. Mock.

I want to explain, however, the difference between a veteran and a soldier patient. The soldier patient coming back from overseas is often referred to as the veteran. In legal terminology the veteran is the discharged soldier. He comes back from overseas into our hospitals and is still a soldier patient.

The Veterans Administration is responsible for vocational training; the Medical Department is not. That is the law. We have a very close liaison with the Veterans Administration in placing opportunities before the soldier while he is still in the hospital so he can obtain this vocational training. The Veterans' representative visits with him while he is a patient, discusses with him where he lives, what opportunities for vocational training are available in that neighborhood, and arranges all the details for him if he so desires to partake of vocational training.

The other problem of placement of what we term the limited duty soldier, the man who is disabled in part but sufficiently disabled so he cannot do full military duty, is this: We have placed in our hospitals members especially trained from the Adjutant General's department, classification officers, who are capable (with the professional staff) of determining what particular type of duty this man with this individual disability can perform in the Army. That is a new step. It is only just being put into effect, and classification personnel are being carefully trained by the Adjutant General to do this.

I will close by saying that I think I have told you all that we are doing now. We are training these men in these schools to go back into the hospitals or into the centers so that they will know what a patient is. The difficulty has been that the physical training, particularly, has been done by non-commissioned officers who have handled normal men, and they think that these trainees are like normal men. Well, in this school we teach them exactly what they can do and what a patient is.

## REPAIR OF CRANIAL DEFECTS WITH TANTALUM

MAJOR FRANK H. MAYFIELD AND CAPTAIN LOUIS A. LEVITCH  
MEDICAL CORPS DENTAL CORPS

ARMY OF THE UNITED STATES

**S**URGEONS have long sought a satisfactory material for the repair of cranial defects. In 1670, J. van Meeccan<sup>1</sup> reported the successful use of dog bone for this purpose. A review of the literature by Grant and Norcross<sup>2</sup> in 1939 revealed that many different materials have been utilized. These included animal and cadaver bone, and autogenous osteoperiosteal grafts from virtually every possible donor site, and many foreign materials such as gold, platinum, aluminum, silver, and celluloid. Since 1939, the use of vitallium,<sup>2,3,4</sup> ticonium,<sup>5</sup> plexiglas,<sup>6</sup> and certain acrylic resins have been described. While many of these have proved reasonably satisfactory, none have all the properties that should be inherent in the ideal substance for cranial repair.

Such a substance should not produce inflammation or foreign body reaction when implanted in tissue. It should have strength equivalent to that of the skull, yet it should be malleable to permit molding with reasonable ease, and should not be resorbed. Tantalum more nearly meets these requirements than any other material yet used in surgery.

Burch and Carney<sup>7</sup> introduced tantalum into surgery in 1940, using it in the form of bone plates, screws, and as suture material. Their experiments and clinical observations, and those of Burke<sup>8</sup> proved conclusively that tantalum induces less tissue reaction than any other metal. Pudenz<sup>9,10</sup> was quick to appreciate its potential value in neurosurgery and began experiments to test its usefulness as a material for repair of cranial defects, and also as a hemostatic clip. It is now in general use in the Army and Navy for cranioplasty.

Tantalum is a metallic element, the seventy-third in the periodic table. It is bluish-grey in color and is malleable and ductile. It was so named by its discoverer, Ekeberg, because of his tantalizing experiences trying to dissolve it.

Since January, 1943, it has been used by us to close cranial defects in twenty cases. The oldest case has been done seventeen months,

the most recent only one month. The follow-up is too brief to permit final conclusions to be drawn, but the results have been sufficiently encouraging, we believe, to warrant recording, especially since they

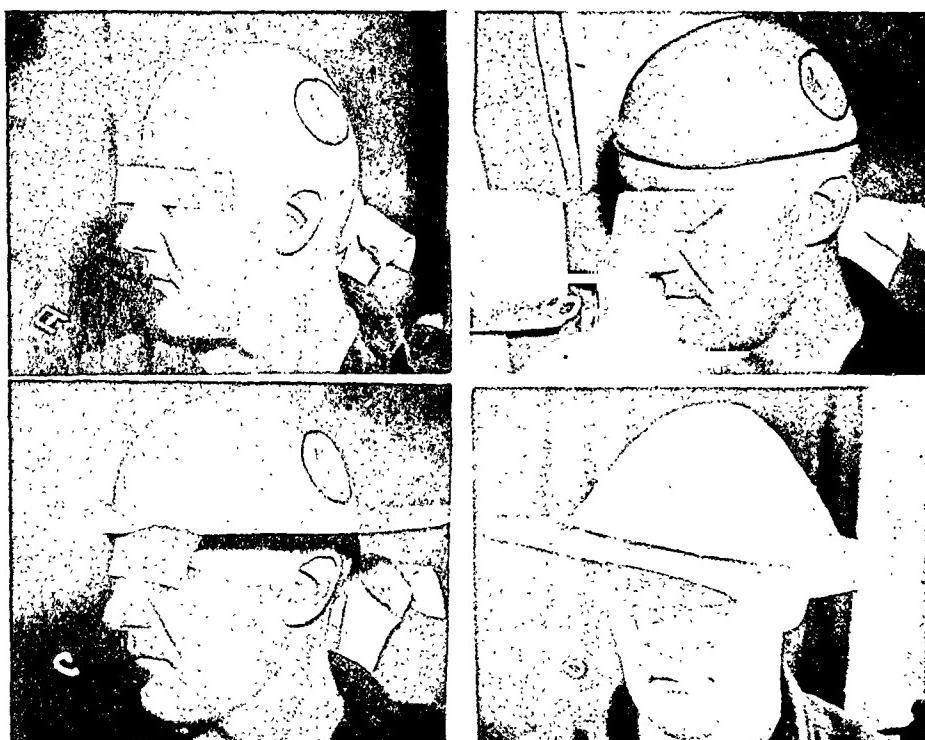


FIG. 1. A, size and shape outlined with indelible pencil. B, contour of heat obtained with flexible lead wire. C, Base-board for plaster. D, plaster impression of calvarium.

are in substantial agreement with those of many others whose work is not yet published.

The purpose of this paper is to present the data from the twenty cases referred to and to describe a technic of preparation and insertion of the plate.

#### INDICATIONS FOR OPERATION

The indications for repair of cranial defects are: (1) Anxiety due to fear of trauma to the brain; (2) the syndrome of the trephined which consists of headaches and dizziness with change of position and with cough, and of extreme intolerance to vibration; (3) unsightly deformity; (4) defects that pulsate unduly or are painful; and (5) protection from trauma.

Grant and Norcross<sup>1</sup> list epilepsy, when that disease arises from the injury, as an important indication. Our experience is not in accord with this.

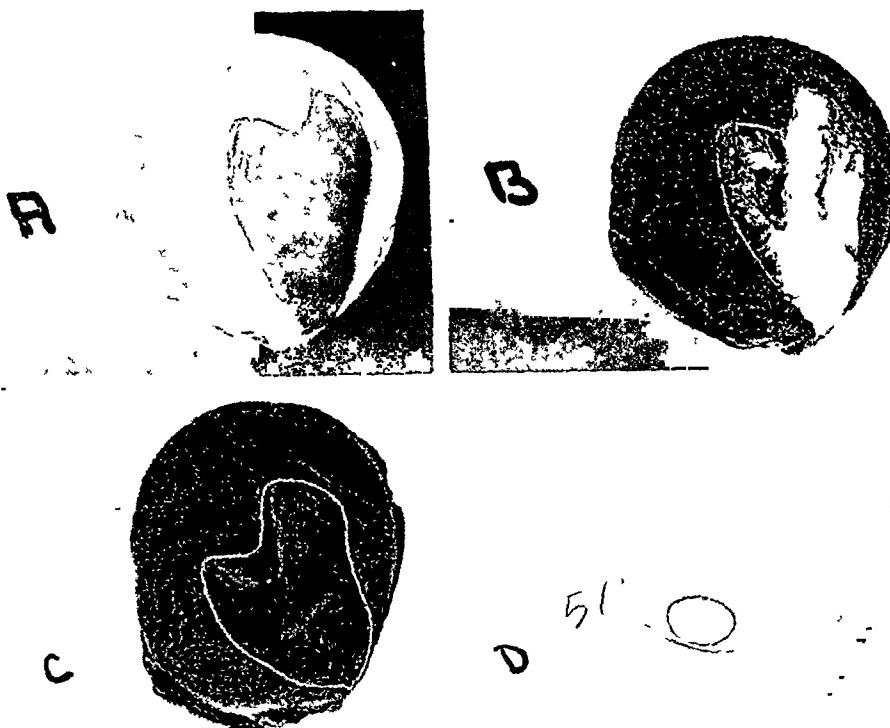


FIG. 2. A, defect filled with dental wax and carved symmetry. B, defect covered with silver foil to facilitate separation of wax. C, outline of defect on skull. D, outline of defect transferred to plaster impression.

Contraindications to operation are the presence of infection or a recent history of sepsis and disease that may lead one to anticipate further surgery of the skull or brain in the area.

It is, however, unnecessary to repair many cranial defects that are small and which cause the patient no concern.

#### PREPARATION OF THE PLATE

Though tantalum may be molded at the operating table, the procedure is time consuming and the cosmetic result is not always good; therefore, the plate is prepared in advance. In earlier cases plates were formed by hammering. More recently a modification of the press and dye principle developed by McCall has been used. The plate can now be prepared quickly and fits more exactly.

Baker<sup>11</sup> has demonstrated that this method can produce plates of the most complex pattern with great accuracy.

From a plaster of Paris impression of the skull deformity, a

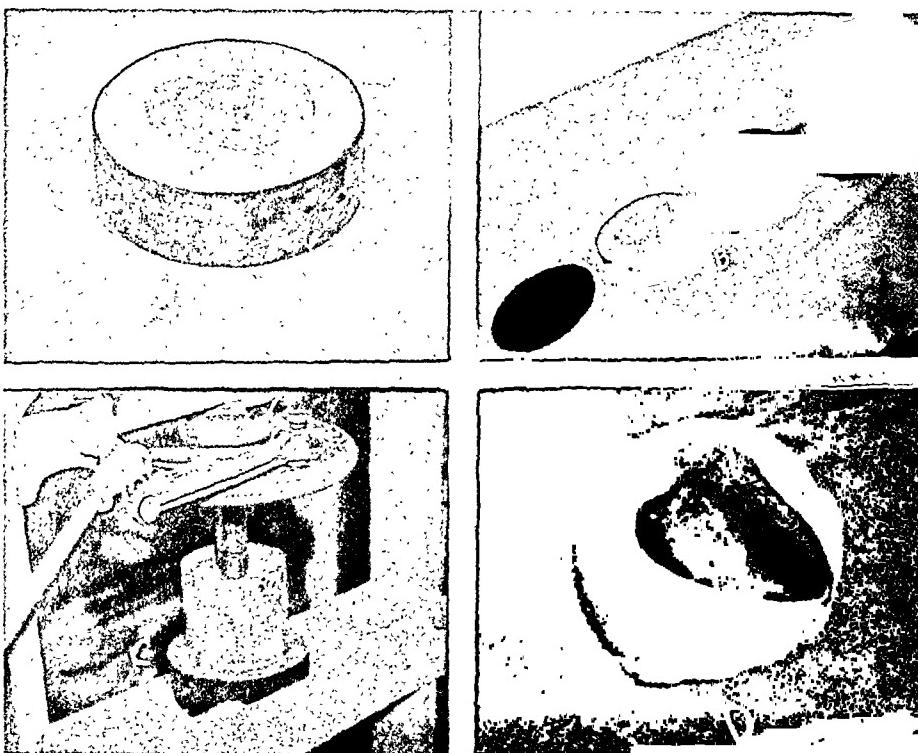


FIG. 3. A, female mold in dental stone. B, metal flask, rubber pad, female mold, pressure plate. C, screw jack press. D, completed plate on plaster model.

female mold of the desired size and shape is prepared of dental stone. The mold is placed in a metal flask and covered with a sheet of tantalum cut to shape with approximately  $\frac{1}{2}$  cm. overlap. The tantalum is then covered with a heavy rubber pad and by means of a screw-jack press the plate is molded. Plate of .0125 to .025 inches provides adequate strength yet molds easily. The details of the technic are explained in the titles of the illustrations. (Figs. 1, 2, and 3.)

#### OPERATIVE TECHNIC

The defect is exposed through a scalp incision planned to consider the healed scar. The prepared plate which bears many perforations is then fitted over the defect. (Fig. 4.) The edge of the

plate is crimped to fit into a shallow groove in the outer table, the groove encircling the defect. This groove may be cut quickly with a high speed dental burr or with a chisel. While the cosmetic effect

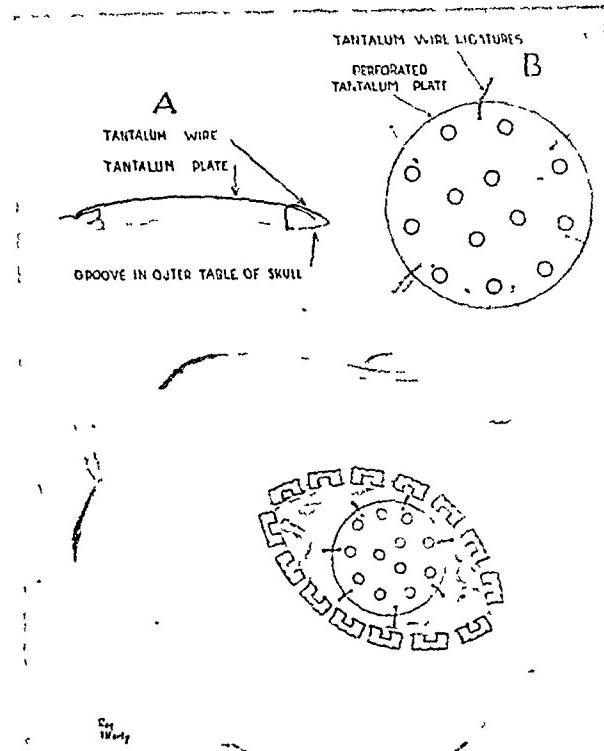


FIG. 4. Diagram illustrating insertion of plate.

is satisfactory when this is omitted, pressure from the hat band or from massage will occasionally cause irritation.

The plate is fixed securely in place with twisted loops of tantalum wire which engage through small drill openings that extend through the outer table of the skull. It is planned that the plate will overlap the defect by  $\frac{1}{2}$  to 1 cm.

Spurling and Homburger<sup>12</sup> fix the plate in place with glazier's points of tantalum. We have felt that countersunk tantalum screws would be ideal. Unfortunately, these are not available in correct size.

The scalp is closed with silk in most instances, but in certain cases in which the risk of infection was considered great, a single layer of tantalum wire sutures have been used. Healing with this method of suturing has been most pleasing.

Control of troublesome oozing is sometimes difficult, but the importance of a dry field cannot be overemphasized.

Cranial defects are for the most part traumatic in origin. Less



FIG. 5. Left,  $\gamma$ -ray showing osteoma of skull. Right,  $\gamma$ -ray of solid tantalum plate in place.



FIG. 6. Postoperative photographs of patient shown in Figure 5.

frequent causes are surgical removal of neoplastic and infected bone. Where skull substance is sacrificed to cure neoplasm, the plate may be inserted immediately. (Figs. 5 and 6.)

Traumatic defects that have not been infected are often repaired within two to three months after healing. Where serious sepsis has been present, we have heretofore required that all drainage have ceased for at least six months before operation. With the advent however of the sulfa drugs and penicillin, we have ventured to

operate within three months after drainage in two cases. One of these, and one clean case, have become infected. These will be reported in some detail as they demonstrate the importance of perforations in the plate.



FIG. 7. Left, preoperative photograph; right, postoperative photograph after insertion of perforated plate. Solid plate had been removed because of infection.



FIG. 8. Photograph of x-rays of patient shown in Figure 7.

#### CASE REPORTS

**CASE 1.** A twenty-eight year old private lost a large segment of the right frontal and temporal bones when struck by a machine gun bullet. Suppuration of the wound developed and drainage persisted for five months, during which time three operations were done for osteomyelitis. There had been no drainage for five months when cranial repair was under-

taken. The defect was covered with a solid tantalum plate, even though a droplet of pus was encountered beneath the scalp. A quick smear of the pus had shown no organisms, but culture recovered the non-hemolytic staphylococcus aureus. Sulfadiazine had been given preoperatively as a prophylactic and this was continued.

The scalp wound healed per primam and the patient appeared quite well except for a slight but persistent elevation of temperature. It was necessary to aspirate straw-colored fluid from beneath the scalp for a few days. Thereafter the scalp appeared adherent to the plate. At the end of a month redness of the overlying skin appeared and again a few cc. of straw-colored fluid were obtained on aspiration, from which was recovered the non-hemolytic staphylococcus aureus. Previous aspirations had been sterile. Incision and drainage was carried out and penicillin therapy was instituted locally and systematically. Within one week all redness and inflammation was gone and the patient's temperature was normal. Signs of infection reappeared promptly, however, when penicillin therapy was discontinued. Eight weeks after operation the plate was removed. Approximately 3 ounces of thick yellow pus was found entrapped between the plate and the dura. Prompt healing of the wound occurred with continued penicillin therapy.

Six months after healing the same plate, now perforated, was re-inserted. Convalescence in this instance was entirely uneventful and now, six weeks after operation, there is no evidence of inflammation and the scalp is firmly adherent to the plate. (Figs. 7 and 8.)

*Comment.* It is believed that had the original plate been perforated that adequate drainage would have occurred and that penicillin therapy might then have been effective. Also, it is believed that the likelihood of suppuration would have been reduced because of the improved blood supply to the infected area.

There has been one other infection in the twenty cases:

CASE II. A twenty-six year old private had sustained a depressed fracture of the frontal bone at the age of fourteen. Drainage had persisted for several months, but thereafter the wound had remained healed. The patient had continued to complain of pain in the area of the depression which also caused moderate disfigurement in that the patient was partially bald.

Nevertheless he had, over a two-year period, maintained an excellent military record. He had fought with credit through the entire North African operation, reporting for sick call the first time two days after the Tunisian campaign ended. His complaints were intense pain in the region of the depressed fracture and of profound nervousness. The pain became an obsession and it was decided upon the advice of the psychiatric depart-

ment to elevate the depression. Attempts to mold the bone into normal shape resulted in its being shattered and the defect was covered with a tantalum plate.



FIG. 9. Left, preoperative photograph of forehead defect; right, photograph six months postoperatively revealing no evidence of dimpling.

Within twenty-four hours after operation the wound showed signs of sepsis and the temperature was elevated to 104°F.

The incision had been in the form of a flap and the two lateral limbs were promptly opened, permitting the escape of copious amounts of serosanguineous pus from which hemolytic staphylococcus aureus was recovered. Under local and systemic penicillin therapy all drainage had ceased within two weeks and healthy looking granulations were covering the plate which had been widely exposed at time of drainage. The wound has now been healed for five months.

**Comment.** It is believed that in this instance the perforations permitted drainage and more effective therapy and promoted healing by permitting granulating buds to come up from the dura through the perforations.

It is likely that the infection in this case developed as a breach of technic at operation; however, the possibility that bacteria may have lain dormant in the previously infected wound over many years cannot be ignored.

The objection has been raised by some that perforations might cause disfiguring dimpling of the skin if used over the forehead. Figure 9 shows a case in which a large plate with many perforations was used to close a defect of the forehead. A photograph taken six

months after operation, shows no evidence of dimpling. Furthermore, the patient wrinkles the skin of the forehead normally which indicates that a minimal amount of scar tissue is present.

All plates have been prepared with multiple perforations 3 to 4 mm. in diameter and in no instance has dimpling been noticed in patients who have been followed as long as twelve months.

The scope of this paper does not permit discussion of the various cerebral lesions that will be encountered in patients who have cranial defects. Decision to repair such a defect can be made only after thorough study relative to the underlying brain.

Of the twenty cases here reported the defect was traumatic in seventeen; one resulted from the operative removal of a tumor of the skull; one followed the elevation of an old depressed fracture; and one resulted from the sacrifice of a bone flap at an earlier operation due to osteomyelitis of the skull.

All patients were men. Four were officers and sixteen were enlisted men. The oldest was thirty-two years of age, the youngest nineteen, the average twenty-four. Eighteen of the twenty cases healed promptly without evidence of inflammation or infection. Two became infected; these have already been reported. In two patients retained foreign bodies and extensive cerebral scars were excised at the time of insertion of the tantalum plate. Two patients have had epileptic seizures. One developed attacks prior to operation and these have persisted. One other had his first seizure four months following operation.

Four patients who suffered with the syndrome of the trephined have been completely relieved of symptoms. (Figs. 10 and 11.) All patients have been relieved of the anxiety due to the fear of trauma. Two patients have been returned to duty. Ten have been discharged from the service because of disability other than the cranial defect. Eight are still under observation.

With the exception of the two patients in whom wound infections developed, healing has been prompt and the appearance of the wound as satisfactory as if no foreign body had been implanted. Occasionally, it has been necessary to draw fluid from beneath the scalp for two to three days and in two patients moderate subgaleal hematomas occurred which were controlled by aspiration also within three days.

Patients with a large dead space between the plate and dura have been kept in bed ten days with the site of operation dependent.

All others have been allowed out of bed from within four to five days. All are kept under constant observation for at least two months before discharge.



FIG. 10. Left, preoperative photograph of patient with syndrome of the trephined, relieved after operation. This syndrome is more frequent in patients with defects over vertex into which the scalp recedes. Right, Postoperative photograph of patient with syndrome of the trephined.



FIG. 11. Left, preoperative photograph of patient with syndrome of trephined; right, postoperative photograph of patient with syndrome of trephined.

#### SUMMARY

The data from twenty cases in which cranial defect was repaired with tantalum have been presented. The technic of preparation and insertion of the plate has been discussed.

## CONCLUSIONS

1. Tantalum more nearly fulfills the requirement of the ideal material for cranial repair than any other material now in use.
2. The plate should be perforated.
3. The plate should be anchored securely in place over the defect with its edge seated into a groove in the outer table of the skull.

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## DISCUSSION

JOHN RAAF (Portland, Ore.): When Major Mayfield asked me to discuss his paper I could think of no good reason for doing so for I have had no experience with tantalum. Tantalum and pantopaque are still not available to civilian surgeons and those of us on the outside are very envious of our military colleagues.

I have used vitallium plates to close cranial defects and have been pleased with the results. I am thoroughly convinced that large cranial defects are more satisfactorily closed with metal plates than with any other type of material such as celluloid or bone.

As Major Mayfield has pointed out it is important to have holes through the plate. If holes are not placed in the plate, serum may collect beneath, elevating the plate. Also the holes allow tissue to grow through the plate and hold it solidly in place.

The splits in the plate are also important because they allow the surgeon to modify the shape of the plate at the time of surgery whereas if the plate were solid it would be too rigid to bend. Vitallium skull plates are not as brittle as I at one time thought. A vitallium plate can be cut with a pair of tinsnips and molded into shape with a pair of pliers at the operating table. Vitallium, however, is not as pliable as tantalum.

I have heard that tantalum will disappear when x-ray therapy is given. I do not understand the process and would like to ask Major Mayfield regarding this point.

I agree that if the patient with a skull defect has convulsive seizures the repair of the defect by means of a metal plate will not alter the occurrence of the convulsions.

HARRY MOCK (Chicago, Ill.): I wish every man, every father and mother, could visit these general hospital centers and witness what I witnessed at Percy Jones Hospital just a week ago.

It was the most thrilling experience of my professional life to see all of these head injury cases gathered together there in two wards, to see 250 amputation cases, scores of osteomyelitis, fifty or so nerve injuries, and to see the care that these boys are receiving, to see the anxiety on the part of the medical officers not to have infections, and to get the best results. As I say, it was one of the most thrilling experiences I have ever had.

I visited Major Mayfield's wards and saw practically every one of these cases that had the tantalum plate repair. Most of you know my interest in skull fractures. I was especially interested in these cases. I think he has developed, with the other men in the country who are using it, an excellent method of repairing these defects, and one that will be a great contribution to surgery.

The opportunity of handling a great number of cases, such as they have, will put it across much faster than the here-and-there treatment by some of us individuals in civil life.

I just want to congratulate Major Mayfield upon his paper, but more upon the excellent work that I saw him doing over at Percy Jones.

COLONEL LAURIE H. MCKIM (Royal Canadian Army Medical Corps): I should just like to ask Major Mayfield one question: I have been informed that tantalum is now being used in the method that he has described, but also in various other parts of the body in the form of wires, tubes, and so on; I have also been informed that it is particularly susceptible to overheating by diathermy.

I would like to ask Major Mayfield whether he has any information on that subject, and also on the story that Dr. Raaf has just spoken about, concerning its behavior under the x-ray.

MAJOR FRANK H. MAYFIELD (closing): Dr. Venable and his co-workers have proved the value of vitallium in surgery. While vitallium produces a

greater tissue reaction than tantalum, the difference is not great enough to be of any practical importance. Vitallium, however, is not malleable and, for this reason, is not readily adaptable for cranioplasty. Cranial repair often requires plates of complex patterns.

In reply to Dr. Raaf's question, I would say that I have no information which leads me to believe that x-rays will dissolve tantalum in tissues. If this is a fact, I am not familiar with it.

Colonel McKim's question as to diathermy is a very pertinent one and this property of tantalum for a while caused us considerable concern. Diathermy will heat any metal, particularly the edge of a thin plate, for the discharge of an electric current from a metal plate is at the edge. This is the principle of the electrosurgical unit.

We have run certain clinical experiments on members of the staff, which consist of holding bits of tantalum encompassed in the palm of the hand while exposing the hand in a diathermy field and there is no appreciable heat if the metal is thick. If the metal is thin, such as in the case of foil, the margins become quite hot, and if the metal is allowed to remain exposed without being encompassed in the hand, the margins become red hot and disintegrate with fire. This, however, is true also of silver and other metals. Since tantalum implanted in the tissue will be bathed in tissue fluids, it is unlikely that any tissue damage will result from the application of this mode of therapy. Nevertheless we do not use diathermy on anyone in whom any metal has been implanted. The patients who have such implants are advised of this potential risk when they leave our care. I should add that there are certain experiments underway which will solve this question.

# COMPOUND FRACTURES OCCURRING IN THE ARMY

## FACTORS INFLUENCING TREATMENT

MAJOR WILLIAM F. STANEK AND CAPT. WENDELL C. PETERSON  
MEDICAL CORPS, ARMY OF THE UNITED STATES

THE present war has increased discussion of the methods of treatment of compound fractures. Articles which seek to apply civilian experiences to the care of war wounds often show an incomplete understanding of the fracture problem in the Army. The character and mechanism of the injuries incurred in various types of service must be appreciated so that treatment methods may be planned to insure maximum benefit to the most severely wounded man.

In order to point out certain factors which influence the treatment which may be given an injured soldier we have reviewed the compound fractures seen by us in three different installations. The first group of cases were from a replacement training center. No heavy weapons were in use and the training was largely concerned with the handling of Signal Corps equipment. During a period of eighteen months twenty compound fractures were operated upon in the hospital. Falls from poles caused four of these injuries, the usual result being a fractured tibia and fibula. Car accidents accounted for five cases. Only one soldier was shot during training. Crushing injuries sustained in falls beneath freight cars necessitated partial amputation of three hands and one foot. The following cases are representative of the group:

CASE I. A private sustained a compound fracture of the lower end of the right tibia and fibula in a fall from a telephone pole. He was treated by immediate débridement and irrigation. A vitallium plate was applied to the tibia with as little disturbance to the periosteum as possible. Sulfanilamide was dusted in the wound and primary closure done. The fracture healed without complications and the patient returned to duty.

CASE II. A private was struck from behind while pushing a stalled car. He sustained a compound fracture of the lower third of the right femur, a compound fracture of the head of the right fibula, and a severe wound of the popliteal space with severance of the popliteal vein and the peroneal nerve. He was admitted immediately, treated for shock, given

500 cc. of plasma and careful débridement was done. The wound was packed with vaseline gauze and a well padded cast was applied. Twenty-four hours later the foot showed dry gangrene. Edema and crepitus in the leg sug-



FIG. 1. Case III. A, roentgenray at time of injury.

gested an early gas bacillus infection. A flapless amputation was performed, and examination of the vessels in the popliteal region showed complete obliteration of the lumen of the artery by clot. Twelve days later the wound was inspected, found clean and healing well. The amputation was revised and the wound healed without infection.

CASE III. A private fell from a pole and sustained a compound fracture of the tibia and fibula. He was treated by débridement and plating of the tibia, vitallium screws and plate being used. Primary closure was done. Twenty-four hours after operation he developed respiratory distress, petechial hemorrhages on the skin, and severe mental confusion. The diagnosis was made of the presence of fat emboli. The patient made a complete recovery and returned to duty. One year later a sinus tract developed near the lower end of the plate. The plate was removed but only after the screw heads were broken off since the screws could not be dislodged from the bone. The patient again returned to full duty.

None of these wounds became infected, although prior to the issuance of specific instructions against the procedure primary closure was used when there was no skin loss, the wound was clean,



FIG. 1. Case III. B, roentgenray thirteen months after injury.

and immediate treatment could be instituted. The healing in these cases did not differ from that expected in simple fractures. Note, however, that few of the cases showed more than moderate contamination. Every case reached a well staffed operating room where definitive treatment could be given within an hour of the time of injury. The injured came in singly allowing the expenditure of sufficient time, help, and thought to select the most appropriate treatment. In the case with the popliteal vessel damage constant observation was possible and justified an attempt to save the leg.

Except in the cases requiring amputation there was no gross soft tissue damage or severance of major nerves.

This is civilian type practice at its best. The results show only

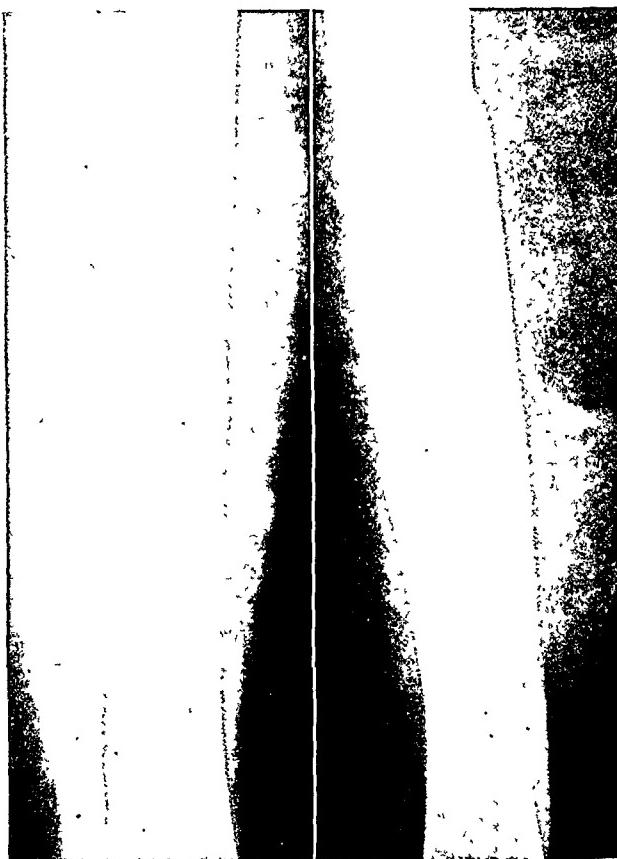


FIG. 1. Case III. C, roentgenray, fourteen months after injury, showing shafts of vitallium screws broken off in the bone cortex.

what happened under ideal circumstances. They are no aid in planning the treatment of war wounds.

The compound fractures incurred in a mountain training center were of a distinctly different character. Certain injuries were peculiar to the type of training given. Winter brought severe skiing injuries. One soldier, caught in a snow slide, was thrown violently against a rock at the bottom of a slope and received a compound fracture of the tibia. It was ten hours before his arrival at the hospital. In spite of this, treatment consisted of débridement, plating of the fracture and primary closure of the wound. Another soldier struck a snow

covered rock. He sustained a compound, comminuted fracture of the right patella which was treated by débridement and wire fixation. Both of these wounds healed by primary intention.

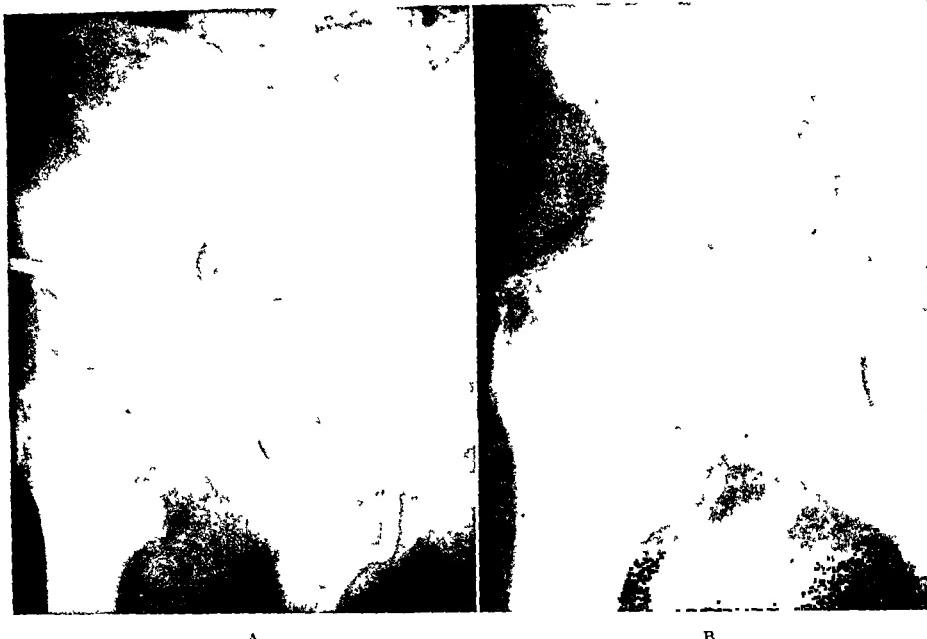


FIG. 2. Case vi. A, roentgenray taken five months after injury, showing sinus tract through the hip outlined by lipiodol; B, roentgenray of right hip taken eight months after injury.

During the summer months classes were given in rock climbing. Men struck by rock knocked loose by those above them sustained compound injuries of the hands. Others were injured in falls. The following was the most severe injury incurred in this manner and was the only patient who developed gas gangrene:

CASE IV. An instructor fell 35 feet to the base of a cliff where the mule corral was situated. He sustained a compound fracture of both bones of the right forearm. Several hours elapsed before his arrival at the hospital. Prophylactic x-ray radiation as well as serum treatment was given as a precaution against gas bacillus infection. Local procedures consisted of débridement, dusting of the wound with sulfanilamide and loose packing of the wound. Forty-eight hours later gas gangrene developed. Wide incisions were made, zinc peroxide was used locally and gas anti-serum and x-ray treatment were given. The infection subsided but thrombosis of the vessels in the anticubital space resulted in dry gangrene of the forearm. An amputation was later performed at the site of election above the elbow to remove a useless extremity.

About half of the fractures were incurred under simulated battle conditions. Blast injuries, ranging from compound fractures of the fingers to wounds of the utmost severity were received while attempting to improvise land mines and grenades from dynamite. The following case was typical of this group:

CASE V. A private in the engineer corps, while drilling a hole through a stick of dynamite, sustained compound fractures and partial amputation of both hands, a compound fracture of the right femur and was partially disemboweled. The fractures were treated by débridement and sulfanilamide crystals were placed in the wounds. This soldier died from infection in the abdominal wound.

At this mountain camp it was observed that wounds incurred while the snow was on the ground only infrequently become infected. Snow lessened the likelihood of contamination and the cold permitted the extension of the time period during which wound closure might be attempted. The closure of a wound ten hours after injury, while successful in the case reported, was not wise. There was little likelihood of avoiding infection regardless of the precautions taken in the case of the man who fell into the heavily manured corral. Review of completed cases in which multiple injuries were sustained left the impression that in such circumstances the ideal primary treatment of each individual lesion was rarely possible.

The remainder of our patients have been treated in a general hospital. They arrive from two sources. Some are brought in from nearby camps and airfields and present the same characteristics as those already discussed. They may have had little preliminary treatment or primary care may have been completed. The remainder have been returned from overseas. The majority of the casualties have been injured by small arms fire. These are rifle or machine gun wounds rather than the self-inflicted shotgun injuries occurring in this country, of which we have seen seven instances. These cases illustrate the difference between battle and civilian type compound fractures. The missiles produce bizarre, complicated injuries. There is often damage to nerves without severe injury to closely related structures. One may surmise that had the path of the bullet been slightly different, and had a nearby large vessel been cut, either immediate death from hemorrhage would have resulted or amputation would have been necessary. Men survive with wounds which one would previously have presumed to be almost surely fatal. One case illustrates this:

CASE VI. A sergeant was shot at close range with a rifle bullet which entered the left buttock, penetrated the ilium, traversed the pelvis, and emerged through the right ilium, fracturing the acetabulum and the femoral neck. He was treated immediately by an exploratory laparotomy and suprapubic cystotomy, and was placed in a cast. Six weeks later it was noted that a fistula existed between the bladder and the right hip wound. The hip showed fibrous ankylosis. Ten months after the injury the bladder was opened and a mass of granulation tissue on its right posterior wall was removed. As the tract was curretted it led into a pocket the size of a hen's egg from which a stone was removed. The bladder opening was closed with a purse-string suture, and a suprapubic catheter was left in place. Five days later the tract from the right hip was explored, the hole through the ilium was enlarged and a large amount of necrotic bone and granulation tissue was removed, the wound being then packed open. Healing progressed well for a month. A small amount of urine was then noted to drain from the hip wound. The sinus closed after three weeks and there has been no further drainage. In spite of the severity of his injuries, this man's general condition remains good.

Bullets as well as shell fragments may produce large irregular defects in the soft tissues, and may carry away major portions of the bone. In such wounds any attempt at closure would be futile. The fragments of metal and the sequestered bone still in the soft tissues when the patients reach the United States show why surgeons concerned with definitive treatment have so frequently condemned attempts at primary closure even though this may appear perfectly practicable to the medical officer giving the primary treatment.

These battle wounds emphasize the necessity for doctors writing on the subject of compound fractures to define the type of case under consideration clearly, both as to the extent of injury and the circumstances of its occurrence. Only this will prevent over enthusiasm for specific types of treatment. Any discussion of the possibility of primary wound closure, backed up by the use of sulfonamides or penicillin must not ignore the fact that casualties are seen by a succession of medical officers and that no record takes the place of daily care by the same physician.

Our casualties are treated in accordance with specific instructions from the office of the Surgeon General. These include adequate exposure with care to avoid over excision of the skin, removal of readily accessible foreign bodies, particles of bone separated from the periosteum, and devitalized tissues. Tight packing of the wound is to be avoided. Later instructions concerning emergency surgery for the extremities have strictly forbidden the closure of any com-

pound fracture of extensive wounds of the extremities. The patients reach the general hospitals in this country in satisfactory condition and radical alterations in the plan of treatment already started are rarely necessary. Except for those patients having injuries of the femur or trunk, most of the men are ambulatory. Their general condition is good and the immobilization routinely used has usually maintained fragments in good position and has afforded relief from pain. Generalized infection is seldom seen and review of the original notes concerning the injuries reveals that a surprising amount of healing has taken place during the period of evacuation to this country.

Fractures of the femoral shaft occasion the most difficulty in treatment. Adequate immobilization for transportation is difficult to attain. During the time necessary to return a man to the zone of the interior there is increased atrophy of the soft tissues, the cast becomes loose, and posterior bowing of the femur is the result. By the time the patient reaches his final destination, the callus may prevent correction by traction or other non-operative methods, forcing a decision to refracture the femur or to accept a poor anatomical result.

Our patients show a high incidence of limitation of motion of the joints, especially limitation of knee flexion and loss of finger motion. Where the medical officer giving the primary treatment has impressed upon the soldier the necessity of keeping his hands mobile there is much less tendency to ankylosis of the joints. Loss of knee flexion is a hazard in any treatment of femoral shaft fractures. Danger of this complication is increased by transportation in plaster, and early joint motion is more difficult to obtain than in patients treated in civilian hospitals. Intensive physiotherapy, when the knee has already lost motion, is hampered by the fact that union may not be solid and that walking can be carried out only in a non-weight bearing calipre which does not permit the knee to be bent.

A few patients have had pin fixation overseas. In addition to the often mentioned danger of non-union, we have noted that the patient is not as ambulatory as he is supposed to be. Fractures of the femur arrive with full hip spicas supplementing the pins. In one instance, generalized edema of the extremity disappeared as soon as the apparatus was removed. This man had shown no more than the usual drainage around the pins. Non-union of a tibial shaft fracture was seen in another patient treated by pin fixation. There had been drainage around the pins but it had not been considered that

dangerous infection existed. A later attempt at bone grafting was followed by osteomyelitis. Since the operative field extended into the site of previous pin insertion the pins are considered the cause of the infection.

We have not used penicillin in the primary treatment of compound fractures or in the initial stages of infection. Our experience with its use in chronic osteomyelitis following fractures has not been great. The cases have usually shown a multitude of organisms in the wound. All sequestra and accessible foreign materials were removed from the wound before therapy was instituted. There has been no instance of a cure by penicillin alone. A distinct lessening of the drainage occurs during treatment even though the predominant organism is not penicillin sensitive. The patients frequently remark that they feel better. Later, drainage may again increase but the general improvement noted makes the treatment of value. Patients who are able to localize their infection, heal up promptly as soon as dead tissue or foreign bodies are removed, even though no penicillin is given. Where, after successful skin closure, bone grafts have been placed in previously infected fields, the use of sulfonamides and penicillin has not always prevented flare-up of the old infection. Their use appears to lessen its severity and may prevent the loss of some of the grafts. Penicillin may not prove a magic drug in the treatment of infected, old, compound fractures.

In the care of battle casualties surgical shortcomings indicate that a team is better than an individual. The army recognizes this, requiring transfer of certain types of cases to special centers. The orthopedic surgeon must frequently call upon the plastic and the neurological surgeon. The closure of skin defects is of vital importance if bone surgery is to be successful and hospitalization is not to be unduly prolonged.

#### CONCLUSION

Plans for the care of compound fractures must be modified by the circumstance under which the accident occurs, the extent of the injury, and the damage done to structures other than the bone. Experience in the treatment of civilian type compound wounds is only of limited value in planning the care of battle casualties. The necessity of combating the stiffness of joints must be constantly kept in mind. The nerve and soft tissue damage complicating compound fractures show the need of interlocking the so-called "surgical specialties" in order to obtain the best results.

## TREATMENT OF FRACTURES IN THE COMBAT AREA

MAJOR BOARDMAN M. BOSWORTH  
MEDICAL CORPS, ARMY OF THE UNITED STATES

THE treatment of fractures in forward surgical installations of necessity differs radically in many respects from that which can be undertaken further to the rear. It is difficult for the experienced surgeon, old or young, to realize this at first and to modify his concepts of treatment accordingly. I certainly found this to be true in the North African and Sicilian campaigns. At or near the front there is only one golden rule by which all surgical procedures must be judged, that enunciated by the Surgeon General: "The greatest good to the greatest number." Under this, three guiding principles or objectives must always be kept in mind: You are there (1) to save life, (2) to save limb and (3) to get the patient back just as quickly as you can. Nothing else matters.

Fractures at the front presented peculiar problems. Early and safe transportation is a prime consideration. Secondary only to this, treatment must be designed for the comfort of the patient and the convenience of his handlers. Multiple injuries complicate the treatment. In a large proportion of cases we had to treat not just a badly compounded fracture but a patient with that plus a skull injury, penetrating wounds of the abdomen or chest, or severe lacerations of the other extremities as well. One's ingrained ideas of what constitutes the best fracture treatment have often to be compromised. Care of the fracture must not only be subordinated to care of the patient but must be molded to fit the requirements of peculiar circumstances and conditions.

Lack of equipment is a very real factor in combat areas and he will be most successful who is ingenious at improvisation. At one time I used a broomstick and tentpole as a Hawley table in applying a spica over a fractured femur. (Fig. 1.) The patient's buttocks were placed on the broomstick supported by two up-ended empty medical chests. His crotch was drawn up against the padded center pole as a perineal bar and his shoulders rested on another up-ended medical chest. I knelt on folded blankets on the dirt floor while operating and then rolled a very acceptable spica on the patient

over the broomstick which was later withdrawn. Of course this was not intended as a permanent cast but it sufficed to splint the patient during transportation to a well equipped hospital in the rear.

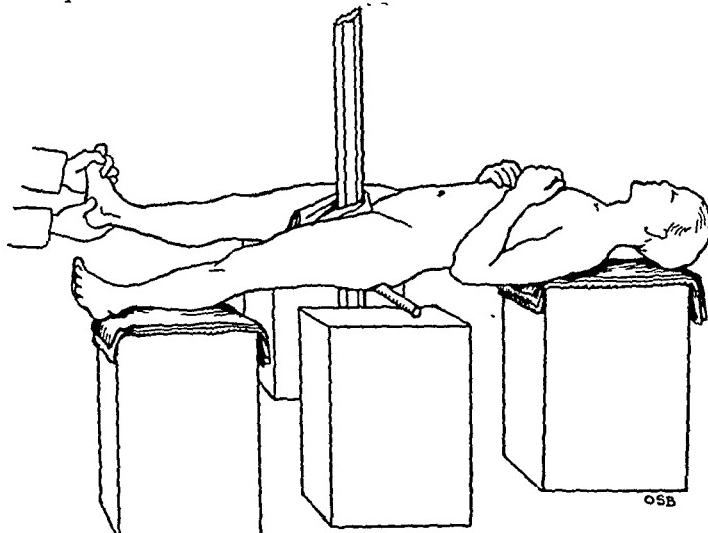


FIG. 1. Position of patient with a fracture of the right femur, supported on broomstick and medical chests, for application of a plaster spica, using the center pole of the tent as a perineal bar.

Similarly, I made a simple but effective Goldthwaite frame for applying body casts and shoulder spicas, using a couple of spring leaves from a wrecked jeep and empty packing cases for a wood base. The ends of the spring leaves I fitted into some old hinges which were pried open and set into each end of the wood frame.

In fact, I designed a basic fracture reduction apparatus in the field and with the aid of a boat maintenance company made it there out of scrap and salvaged metal. It was complete, with pin yokes adjustable in all planes and was open at the base to facilitate x-ray and fluoroscopic examination. It was demountable for transportation in a wood case made to fit, with homemade hinges and hasp of brass shell casing. To top it off, this apparatus was chrome plated, when finished, at Oran, North Africa. True enough, I had occasion to use it on only one patient but it was well worth the trouble of making.

A major complication of war fractures of the extremities which we encountered occasionally was tamponade of the circulation from an unsuspected hemorrhage beneath the deep fascia. If the bleeding was from a large vessel, it quickly made itself obvious but in some cases the process was slow or delayed and presented a

most confusing diagnostic problem. I know of at least one amputation for gangrene which resulted from failure to recognize this condition at an early stage.

In many fractures the bone or bones were terrifically shattered and often enough there was a massive loss of soft tissue as well. We tried to save every limb we possibly could but this can be overdone. If, as occasionally happened, the blood supply to an extremity has been hopelessly compromised by injury, necessary débridement or both, it is not only useless but dangerous to temporize by leaving the limb on; amputation should be performed at once. Violation of this principle has been followed by gas gangrene and disastrous results.

In many cases loss of bone as well as soft tissue has been extensive. All the field surgeon can do is to preserve as much as possible and in the case of *bone* this is most important. We are told to remove loose fragments of bone from the wound but at the primary débridement, if there is any question of remaining attachment of periosteum, it is best to leave the fragments in place. Some may regenerate and those that do not can readily be removed later. This brings up the interesting question of what to do with the occasional sizeable fragments that are entirely loose and are removed. Should they be thrown away, as has usually been done, or carefully preserved and sent on back with the patient as potential autogenous graft material? I must confess I have never done this but in an occasional case it might prove of real value.

A word as to casts. It may be that the unpadded cast technic is a good one in well qualified hands *under certain conditions*, but I believe the skin-tight plaster has no place in the primary treatment of battle fractures in the field. Its use there can not be too strongly condemned. Not only is swelling, edema and circulatory embarrassment to be expected in such wounds, but due to the hazards of mass evacuation no adequate check-up on circulation can be expected, let alone guaranteed. For that reason, no matter what has been a surgeon's previous training or experience, all casts applied in this area must be padded, and then they must be split or bivalved throughout their length. The separation must go not only through the cast but through all dressings and bandages underneath as well, right down to the skin itself. This is important, as blood-caked dressings can restrict circulation just as effectively as any type of plaster encasement.

The so-called Tobruk splint for fractures of the lower extremity was quite popular with the British and Canadians and is applied as shown. (Fig. 2.) A long slab of plaster is placed behind the ex-

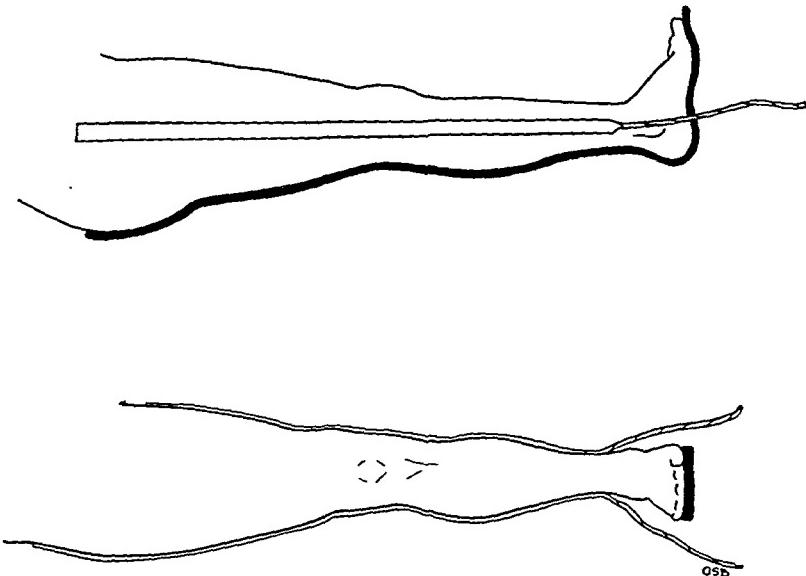


FIG. 2. A, application of Tobruk splint. First stage: posterior mold and adhesive tapes.

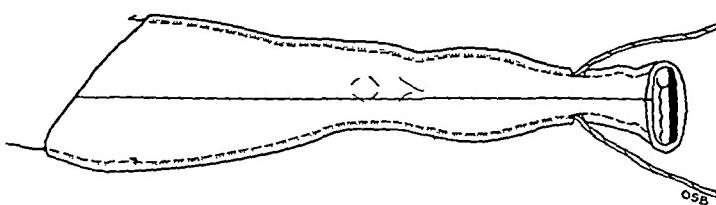
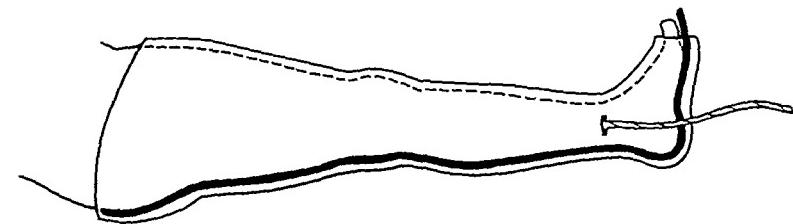


FIG. 2. B, application of Tobruk splint. Second stage: light circular cast, split.

tremity from the toes to well up under the buttock. A three-inch adhesive strip is run along either side of the previously shaved

thigh and leg. Proximal to the malleoli these strips are folded on themselves to make traction tapes. A padded circular cast applied over this is split throughout its length. The traction tapes are led

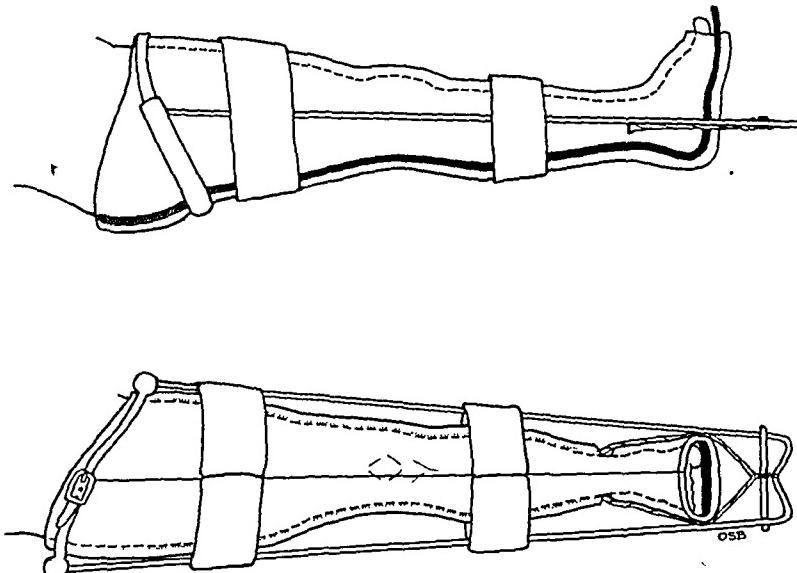


FIG. 2. c, application of Tobruk splint. Final stage: incorporation in half-ring splint with traction.

out through openings left in the cast above the malleoli as the cast is put on. The whole is then incorporated in a half ring splint by a few turns of plaster at midthigh and midcalf. These plaster turns must also be split. Traction is applied in the conventional manner by a Spanish windlass of the adhesive tapes. This type of cast was easy to handle in ambulance or train but in my experience patients were more comfortable in a well applied spica.

Nerve injuries are among the most common and serious complications of war fractures and the possibility of their presence must be kept in mind when the patient is presented for primary surgery. If the case is seen within the first few hours and the ends of a severed nerve can be coapted, this should be done by fine sutures placed in the nerve sheath. Otherwise the nerve ends should be fastened where they are with a small stitch to prevent further retraction and separation.

In the combat area open reduction of simple fractures was not permitted. This was an irksome rule to some of us who were trained in this form of treatment and felt that our surgical judgment was being coerced, but from an overall viewpoint many complications

and bad results were probably prevented by its observance. Compound fractures were another matter. Here the treatment was left pretty much up to the individual surgeon. Yet, as I recall, internal fixation was employed in relatively few instances. One good reason for this was lack of time and the urgent necessity for speedy treatment of large numbers of wounded. Following a careful débridement, thorough lavage of the wound with copious amounts of saline and a loose filling-in with vaseline gauze, most fractures were immobilized for transportation to the rear in a simple plaster cast.

TABLE I  
SPECIFIC FRACTURES

	Simple	Compound
Upper extremity		
Clavicle .	Figure of 8	Figure of 8
Scapula	Shoulder spica	Shoulder spica
Humerus, head	Shoulder spica	Shoulder spica
Humerus, shaft	Hanging cast	Hanging cast
Elbow	Shoulder spica	Shoulder spica
Olecranon	Circular cast in flexion	Circular cast in flexion
Forearm: 1 bone	Circular cast	Circular cast
Both bones	Circular cast	Plating and circular cast
Metacarpals	Circular cast	Circular cast
Lower extremity		
Pelvis	Double spica	Double spica
Femur, head	Spica or Tobruk	Spica or Tobruk
Femur, intertrochanteric	Spica or Tobruk	Spica or Tobruk
Femur, shaft	Spica or Tobruk	Plating and spica
Patella	Circular cast in extension	Circular cast in extension
Leg: 1 bone	Circular cast	Circular cast
Both bones	Circular cast or Tobruk	Plating and cast unless fragments could be locked
Ankle and metatarsals	Circular cast	Circular cast
Os calcis	Circular cast	Circular cast

#### Spine

Body cast, with an extension of molded posterior shell to support the head if the fracture was in the cervical region.

When some form of skeletal fixation was imperative I preferred plates of vitallium or stainless steel to the Roger Anderson and similar pin transfixion methods as being much quicker, surer and simpler. I found the fracture could practically always be approached by incision through a clean area. The wound of compounding, after débridement, was loosely filled with vaseline gauze and left open.

Counter (dependent) drainage, especially of compound femoral shaft fractures, was often employed with benefit.

Lack of time precludes a detailed description of the treatment given specific fractures but Table I shows how the more common types of fractures were handled by us. Bear in mind that this work was all primary combat surgery done under pressure in the field, limited by directives and with the prime objective—cleansing of dirty wounds and adequate immobilization of fractures for prompt evacuation to the rear.

Please observe that we used a great deal of plaster and very little hardware. As a rule these patients reached larger, better equipped installations far to the rear, where definitive treatment of the fractures was undertaken, within one to four days after leaving us. We had good x-ray facilities and were usually able to secure a good or fair reduction between immobilization.

Referred pain from fractures was an interesting phenomenon and sometimes followed a bizarre pattern. I remember being called one night to see a patient with a fractured clavicle for an attack of acute abdominal pain. It was both surprising and gratifying to have the abdominal pain disappear and the spastic abdomen relax as soon as a poorly fitting Velpeau was replaced with a snug figure-of-eight bandage. It may be asked why a fractured olecranon was put up in flexion. I can only say that the patient was transported more comfortably in this position and apparently did well subsequently. Plating was not done in every compound fracture of the femur or of both bones of the forearm or leg. Occasionally, extreme fragmentation of bone or the general condition of the patient rendered this inadvisable.

I recall that we used intravenous sodium pentothal more frequently than any other form of anesthesia in treating major fractures in the combat area. There were a number of reasons for this, the most important perhaps being the ease, simplicity and speed with which it could be administered. In the hands of one well trained in its use there was no difficulty in securing muscle relaxation when required and then reverting to a lighter plane of anesthesia for the balance of the operation. I know of only one minor complication from its use, a temporary cessation of respiration, in several hundred cases and heard of no fatalities for which it could be blamed. Next in frequency came spinal anesthesia for lower extremity fractures. This was very effective but was often a bit awkward to administer.

It always seemed much more of a procedure and consumed more time which in a busy forward installation is an important factor. In a few cases in which one team performed a laparotomy while another treated a fracture or fractures on the same patient inhalation anesthesia was employed with benefit. Many simple fractures, such as a Colles, were reduced with novocaine infiltration directly into the fracture site.

Fractures came to us at the clearing station or surgical hospital generally in pretty good condition. Major fractures of long bones almost without exception were well supported in a Thomas splint which had been applied at a collecting station or by litter bearers on the field. It was surprising to me to see this job so well done on such a large scale. Rare indeed was the patient whose splint was improperly applied or on whom excessive traction had been placed. I believe that this early adequate immobilization contributed more than any other one factor to the generally satisfactory results obtained in the treatment of fractures in the combat area. All credit for it is due to the intelligent, well trained and hard working enlisted men of our Medical Corps.

COMBINED DISCUSSION OF PAPERS OF COL. AUGUSTUS THORNDIKE,  
MAJOR FRANK MAYFIELD, MAJOR W. F. STANEK AND MAJOR  
B. M. BOSWORTH

COL. LAURIE H. MCKIM (Royal Canadian Army Medical Corps): Colonel Penberthy suggested that we might say something about the program of casualty retraining, as we speak of it in Canada. We have such a program, and it is along almost the identical lines that have been outlined so very ably by Colonel Thorndike.

I was rather disappointed that Colonel Thorndike did not mention one point which we think is of great importance in the reconditioning of men, and that is the effect of getting the ordinary patients, the routine operative patients, out of bed at the earliest possible moment. I think there is no doubt that a review of things as they are today would definitely point out that in the past surgeons as a whole have made a great mistake on two particular points: (1) They have kept their patients in bed too long. (2) They have not fed them soon enough and in sufficient quantities after operation.

I think these two points are being attended to very carefully now, and I am sure the results that are being shown by the early getting up of

patients after hernias, and so forth, will amply justify the work under investigation.

There was one point that I intended to mention. In 1917, at the clearing station, called the casualty clearing station, where I was in France, we had a period in the first of December following the first Battle of Cambrai, during which we had no food except condensed milk, Army biscuit and canned beef. We had about 250 abdominal cases. We had no other food for them for a period of about five days, during which time we were snowbound. The roads were blocked as were also the trains. We had to feed those patients on what we had. They did not care very much about the condensed milk, but they ate the beef and the Army biscuits, and I may say that closures of perforated wounds of the stomach and intestines seemed to do rather well on it. That changed my own ideas as regards early feeding after operation.

In regard to Major Stanek's paper, there are a few points I should like to mention. Major Stanek mentioned that in one of his cases he had gas gangrene. He mentioned that he treated this by x-ray. Does Major Stanek think that this x-ray treatment is of any value? I wonder what the majority of the members here think. Personally, I do not think it does any harm, but I question very much whether it does any good.

I certainly would like to agree very fully with Major Stanek's statement that the primary closure of wounds in compound fractures is almost never justified.

Finally, I would like to agree with him on one other point, which I think he might have stressed even more strongly, and that is the use of the newer antiseptics, such as penicillin and sulfonamides, should not under any circumstances allow us to take our mind off the main target, which is that these things cannot take the place of adequate surgical procedures.

With regard to Major Bosworth's paper, he mentioned two points that I think are of great interest. One is the slow bleeding in the tissues with obstruction of the arterial circulation. He mentioned this with regard to wounds. We have recently had a series of cases in Canada and the United States in which we have had gangrene of the toes and of the foot following simple fractures.

Some of our friends tell us that this is due entirely to arterial spasm. I just wonder if it is altogether due to arterial spasm, and whether some of these cases of gangrene of the feet, which have been reported following simple fractures of the leg, are not due to this slow bleeding that Major Bosworth has spoken of.

Finally, Major Bosworth has mentioned the question of cutting plaster of Paris casts. We have recently had a very interesting discussion on the returning of casualties from overseas on our hospital ships, and the officer commanding the surgical division is quite firmly of the opinion that by far

the greatest number of casts that he has had to change on this hospital ship have not been due primarily to too tight a cast, but to a circular bandage over the dressing which becomes soaked; the dressing swells, which causes pressure at the site, and ulceration of the skin from the pressure caused by the bandage and not by the actual pressure from the plaster cast.

COL. ROBERT I. HARRIS (Medical Corps): It is a privilege I greatly appreciate to be at this meeting, and especially to be permitted to take part in the discussion of the papers on military surgery.

I realize that you are paying a tribute to the Canadian Army, and I am happy that with Col. McKim I have been chosen to represent your Canadian military colleagues.

Major Bosworth hoped that what he had shown us would bring to the minds of the "oldsters" in the audience memories of the last war. He has done that, but he has done more than that. He has taught us and shown us how much progress has been made in the management of problems which are fundamentally the same now as they were then. There is no question about the fact that we are managing war wounds with much more skill and with much more success than we managed them in World War I.

It would be impossible for me to discuss the program as a whole, and there is nothing that I can accomplish by attempting to do so. But there are some items in the program about which I should like to speak, and the first is Colonel Thorndike's paper on reconditioning.

If my judgment is correct, the work in reconditioning which has been stimulated by the necessities of this war will be one of the great contributions to medicine that this war makes. If you will recall the experience of the last war, there was a great impetus to things that we now call reconditioning. It was so in our country, and I am sure it was so in your country. It was then that physiotherapy and occupational therapy first started and developed.

But the impetus died in the years between the two wars, and there have been periods when those who have been concerned with reconditioning, have been unhappy about the part that physiotherapy and occupational therapy should play.

There seemed to be too much individual treatment, and too much treatment by the physiotherapist or occupational therapist of the patient rather than stimulus to the patient to be his own therapist. That is to say, there was a stress upon passive therapy rather than upon active therapy.

The great stimulus which the needs of this war has given has emphasized this very point, namely, that to get well and to be reconditioned a man must do things for himself. The basis of reconditioning, in your Army as presented by Colonel Thorndike's paper, and as I know it is planned in our Army, is that it shall stimulate the man's own activity. It shall start at the earliest possible moment so that in a large way he will never get into the

state of poor condition which we have been accustomed to allow our patients to reach. He should be taught what he can do for himself; he should be stimulated and coaxed and cajoled to do these things for himself, and he should be urged to become an independent treater of himself under guidance.

This is important and unless we carry it over into post-war problems, we have made a great mistake. It is of tremendous importance, and cannot be done without profound changes in the training of people devoted to this work.

We train physiotherapists, occupational therapists, and instructors in physical education, and physical instructors. But there is no co-ordination between their training, and often the overlap of their fields of activity leads to conflict and confusion.

If the military program of reconditioning which we are setting up is to be of use after the war, it must go back to the very beginning. It must be based upon a broad concept of what is reconditioning. In my opinion it is much broader than can be defined by "physiotherapist" or "occupational therapist" or "physical instruction." There is more to it than all of these put together.

We must think of setting up courses in physical reconditioning which will include all these branches and more besides.

I agree with Colonel Thorndike that for the successful direction of this work in hospitals there is need of medical officers of a particular type. One of the mistakes we made in the last war was to put the work of the physiotherapist and its handmaiden at that time, occupational therapy, in the hands of certain members of the staff already there—usually the surgeon who was interested in orthopedic surgery. It is perfectly true that the orthopedic surgeon has more interest in this than most people; but on the other hand he cannot devote enough time to it, to planning, to directing, to providing the stimulus to his workers and to the patients, without neglecting his work as an orthopedic surgeon.

We have need of specialists in this field, and part of the success of any program of reconditioning will be dependent upon the selection of skillful men properly trained in this field and functioning well after they have been given command of the work.

Major Stanek and Major Bosworth did well to emphasize the difference between the management of compound fractures in civil life and in war. Major Stanek was correct in pointing out that the fractures we see in the Army in training on this continent are in effect the fractures of civil life. They are comparable to severe industrial fractures or severe road accidents. So it would be wrong, as he stated, to draw conclusions and to lay down principles of treatment based upon compound fractures seen in training.

But in the gunshot wounds with the enormous destructive effect they produce, the ever present contamination with dirt, the certainty that the wound is contaminated with bacteria, the stripped-down simplicity of

surgical equipment and the circumstances under which surgery must be performed, if it is to be done at a time when it will be most effective for the patient, all must be treated with the single purpose of combatting infection. That is the first principle. As Major Bosworth pointed out, the first objective is to save life and to save limbs. Under these circumstances it is obvious that we cannot do in the line what we might do in the training camp.

I was intensely interested in Major Bosworth's firsthand account of what he did, in what we would call a Field Surgical Unit but what he calls an Auxiliary Surgical Team. Far too little of this firsthand experience has come back to us as yet. We learn more by such accounts than by anything else.

COL. AUGUSTUS THORNDIKE (Medical Corps): My experience in the Southwest Pacific was that of Chief of the Surgical Service in a large general hospital. It is well, perhaps, to inform the members that the terrain is a little different in the tropical islands than what Major Bosworth described.

We sent out from our hospital two portable surgical hospitals; that is a new unit. It was promulgated in the Southwest Pacific because of the terrain. The surgical portable hospital consists of four officers and thirty-three enlisted men who carry their equipment on their backs. The patients are housed in tents with cots, and everything is carried by pack.

Transportation is different. At the time of the Buna campaign these surgical teams were operating very much closer to the front than what Major Bosworth described, again because of the difficulty of transporting the wounded to the rear.

I cannot describe it too much in detail, as it is a military secret, but you will find in the December issue of the Bulletin of the Medical Department an account of one of my hospitals that was up in the Buna campaign. That is the December 1943 issue of the Medical Department Bulletin.

Those fellows sweated it out, and they did a marvelous job. They came back to us; they looked like different people. They lost a lot of weight; they had been sick all of them, but they carried on. We now have from that same hospital two other units up in the forward area doing the same thing on these islands at Hollandia and other places.

Again it is a question of bringing surgery and the expert surgical care forward to the patient who is wounded in battle.

Might I open the remarks I closed before, prior to some of the questions Colonel Harris raised.

Concerning Colonel Harris' suggestion about training of the occupational therapist and the others in the whole program, the Manual we are now preparing is in three parts. One part is the physical reconditioning; another is the educational reconditioning, which I believe is the most important factor to have been added to this program; and the third part is the occupational therapy.

Those three functions—officers, enlisted men or civilians, and the occupational therapists who are civilians—will all get three parts of the Manual and become acquainted with how they tie in.

In the occupational therapy field there is a great scarcity of personnel. The War Department has approved a new emergency course to qualify, subsidized, in private schools now existing, a four-month course for civilians and an eight-month apprenticeship afterward in certain designated general hospitals. That is the way the Army is attacking that problem.

Concerning Colonel McKim's remark of getting them out of bed early, I did not mention it but we thoroughly approve of pushing a patient through his early stages of convalescence with adequate physical exercise in bed so that he does get out of bed and does progress from the first day very much more rapidly.

I did not mention the military training aspects of the advanced reconditioning section in great detail, but that is really a rugged course in training.

Lt. COL. RICHARD T. SHACKELFORD (Medical Corps): I hope you will understand that everything I say is my own personal opinion. I cannot back it up with statistics because we have no statistics.

I have been asked to speak about my experience with the so-called combat surgical team which was detached from three of our general hospitals in the South Pacific, namely, the Yale Unit, Hopkins Unit and University of Maryland Unit.

We were assigned to take part in the amphibious landings in the Solomons. Surgery and the surgical care of patients in theaters of that kind is quite different, I gather, at least different from the problems in Italy and Europe. We have no roads, no landing fields, no railroads. It is quite obvious that it is imperative to give complete surgical care, and the best surgical care, on the beachhead on the island at which the landings take place.

There is no road over which to bring back the wounded. They have to be carried back by litter, down a narrow trail, with snipers along the trail. They cannot be evacuated at night. Any man above ground at night is a good target for our men as well as for the enemy.

The work is done in dugouts. If you are lucky you may have a fly tent, but as a rule most of our work was done in a shallow dugout, about nine by six feet in size, covered by a fly tent.

Fortunately, in the landing in which I took part our casualties were less than we anticipated. Also fortunately, the Navy had exactly the same sort of setup that we had, and so the work was not as heavy as we had expected. But there are certain things that did occur to me, and certain things that we learned.

One thing we learned was that abdominal wounds should be operated upon right away—immediately. That is not new. But they should be operated upon regardless of whether the man is in shock or is not in shock. The patients were operated upon with no pulse and no blood pressure. We would get them ten minutes after they were hurt, pulseless and pressureless. We would start plasma in the vein, use ether anesthesia, and that is a point I should like to emphasize: We were all of the opinion that sodium pentothal and spinal anesthesia were contraindicated in the men who were in shock. Most of the patients we got were in shock.

So we started plasma in the vein and started them immediately on ether anesthesia, operated upon them, and on opening the abdomen in the great majority we found active hemorrhage present. If we had waited to give transfusions and various things to bring those chaps out of shock, they never would have come out of shock.

Once the bleeding was stopped with intravenous fluids going through, their pulse began to come back, their blood pressure began to rise, and we could then take our leisure time preparing for the operation on the abdomen, even three or four hours, however serious the case might be.

The second thing that we found, and for which we are hunting a solution (and which was a point in Dr. Loyal Davis' remark that interested me most) was the matter of blood transfusions. Plasma has been miraculous. We owe a great tribute to it and the way it is packaged. You can carry it in your pocket; you can carry it in your pack. That is the way we had to carry things. Our total equipment fitted into two-foot lockers. That is all the equipment we had, that is all we could carry. Each team consisted of two surgeons, one anesthetist and two corpsmen. We had three such teams. That group included one thoracic surgeon and one brain surgeon, but all of us had had general surgical training.

We also carried one laboratory man who was of great assistance because he did the blood groupings and matchings, and we found quite a high percentage of error in the blood groupings that were put on the identification tags that the soldiers carried; so we had to rematch every patient to whom we gave a transfusion.

Using the indirect method of blood transfusion, we found two difficulties: The first one was that in using the ordinary amount of citrate for some reason not known to me or any of us, and the Navy had the same trouble, we found that the blood clotted. We did not know whether that was because blood is more concentrated in the tropics, where everybody is sweating all the time, but we found that we had to use triple the amount of citrate to prevent the blood from clotting.

The second thing we found was that we always got a reaction, and a severe reaction in many instances, so much so that we finally had to abandon the indirect method of blood transfusion and then resort to the

direct method which is nowhere near as satisfactory. In the first place, it ties up three men doing it, and when you are busy you cannot afford to spare three men.

In the second place, with the basins of water down in a foxhole, with various insects of all kinds and lizards and various fauna and flora that seem to abound in that area, we were never quite sure of sterility. But we had to resort to direct transfusion.

It seems to me it would be well for a while, as a project for the National Research Council or any other such agency, to develop a scheme whereby we could have blood and tubing available. Personally, I suspect our trouble was with the tubing. We cannot carry enough distilled water to prepare our tubing properly. But if someone could devise a method which would make the giving of blood as easy as the giving of plasma, I believe our problems certainly would be greatly simplified.

As far as the other treatments of wounds are concerned, they did not differ markedly from Major Bosworth's. We treated compound fractures the same as he did. We débrided them, packed them in sulfanilamide and vaseline and put them in a plaster cast. The plaster cast is a great convenience when transporting men if you have to transport them by litter, which you usually have to do down to a beach and then from the beach put them on either an LST boat or, if you are lucky, make connection with a Dumbo or PBY flying boat, unless the airfield is captured or unless you build your own airfield. The wounded could be put in the planes and transported back to the bases further back.

Concerning soft tissue wounds, we learned one very valuable point from our New Zealand friends. Lieutenant Colonel Wilson, in the New Zealand Army, who had had three years with the 8th Army and who was our fairy godfather in the Solomons, taught us much we did not know about war surgery. He emphasized to us that dependent drainage should be established in all excavated soft tissue wounds. We are quite firmly convinced that Colonel Wilson's point is a good one. So we made a practice of establishing dependent drainage in all large wounds of the soft tissues.

I cannot go further into the medical treatment of patients because I have no statistics and I cannot quote any figures. I wish we had a way, as the New Zealanders have, of following up the patients we operate upon. I do not know whether we did right or wrong in some of the cases. The New Zealanders have a very practical méthode: They have a perforated tag on the EMT tag, so when a patient is operated upon the surgeon at the front puts his name on the tag. When that patient reaches the base hospital and has his final definitive treatment, the perforated tag is torn off, the diagnosis and result is placed on it, and it is mailed back to the New Zealander who did the original operation. In that way he has some idea of the quality of the work that he has done. Unfortunately we do not. I do not know whether we do well or whether we do poorly.

My last point is that as far as the Pacific war is concerned, with the difficulties in transportation and with the delays made necessary by the fact that you have to wait for airplanes for transportation, or boats for water transportation, you never know when it is going to come; it may be several days or it may be an hour. With those difficulties it seems imperative that we have to supply skilled experienced surgical treatment on the island on which the beachhead is established. With that in mind, it seems to me that there are two places in which experienced surgeons are needed as far as the Pacific is concerned: First, right at the front lines where you get patients five, ten or fifteen minutes after they are hit. I believe if such is provided, a good many patients, particularly those with abdominal or thoracic injuries, will be saved.

I noticed in Major Bosworth's figures only 5 per cent of the cases in the general hospitals were abdominal cases. Our Chief of Surgery of the general hospital located well back behind the lines said we have very few abdominal cases, and the reason, I believe (although I do not know) is that many of those men do not survive.

When we think of the remarkable percentage of wounded who recover in this war, I am afraid those figures are based on the number who reached the hospitals further back, and not based on those who reached the collecting companies.

We were working in collecting companies, and in collecting companies I got the impression that our mortality was higher. I do not have the figures, but I did get that impression.

If we can provide trained surgeons in the collecting companies, the wounded can be operated upon right there, and it is surprising how well they do under the crudest conditions. I was not at all disappointed by the number of infections that we got working under what looked like the most unsatisfactory and septic conditions.

So it seems to me that the place for the great majority of your younger, well trained, skilled surgeons is at the front. Otherwise one rehabilitation surgeon and one specialist in each field is all that is necessary, and their chief job is to keep the younger surgeons from operating too much.

I have heard the argument expressed that if this is done, too many skilled men will be lost. I think that is an exaggeration. Life at the front did not strike me as being any more hazardous than crossing 42nd Street and 5th Avenue in New York. In my opinion the doctors should take just as great a risk as the infantryman.

G. F. BERG (Pittsburgh, Pa.): The last remarks were very well taken. I think the Major should be congratulated on being an expert gadgeteer. By that I mean he was able to judge the situation and take care of that situation. With what he had at hand, he was able to devise an apparatus which was life-saving.

There are just a few things I should like to mention: (1) Finger-out or non-finger touch technic in the treatment of any compound fractures. At present you hear very little said about keeping the fingers out of the wound, and allowing only instruments to be handled by the handle, and any part of the instrument that comes in contact with the hand, should not be permitted to enter the wound. I think that over a good many years, the men who have had the most experience and have been trained in that technic, are not nearly so apt to have the wounds re-infected by bacteria placed in the wound as the result of any surgical procedure.

Dr. Leriche called attention in the last war to a type of fracture known as the fissured or the butterfly fracture. An individual who has met with a bad compound fracture, depends upon the original care that he will receive. It has been proved that fissured fractures in which the fissures become contaminated with bacteria or have foreign material forced into them, will develop osteomyelitis unless the foreign material is removed and the fissures thoroughly exposed.

If you take an individual who is in the prime of life, split the periosteum, remove the traumatized or fissured part of the bone, keeping the periosteal tube extended, nature will reproduce a normal shaft. Some individuals think this is not true, but past experiences have proved that nature is remarkable and with proper assistance does some remarkable things. In doing any operation involving a bone, split your periosteum and permit some of the bone to remain attached to the periosteum. I think that every first-aid team stationed near the seat of action, this team being the one designated to do proper débridements of compound wounds, should be provided with good bone holding forceps and three instruments, that resemble chisels. With these it is possible to perform a débridement with dexterity. In removing the periosteum, the tubercle or bony prominence to which muscles are attached should be removed intact with the periosteum.

There is one other thing I should like to call to your attention—the danger factor in the productoin of gas gangrene infection—and that is the inability of the muscular structure to secure sufficient space in which to expand after an injury, unless the fascia which surround it is split.

MAJOR W. F. STANEK (Medical Corps): In answer to Colonel McKim, and not to start a discussion at this late hour, I believe that if I had to give up any one of the treatments used in gas gangrene, I would most willingly give up the x-ray therapy.

MAJOR B. M. BOSWORTH (Medical Corps): In answer to Dr. McKim, I just want to say that I did not see any gangrene resulting from a fracture *per se*, that is, not to recognize it myself.

As regards Lieutenant Colonel Shackelford's discussion which I enjoyed immensely, there are one or two points I think in which my experience differed from his. (1) Receiving the patient in shock and operating upon

him immediately. Our first inclination and action was to do that very thing in the field; but we learned rather quickly that we got better results if we delayed our surgery a little bit and got the patient out of shock, with the single exception of patients with internal hemorrhage. If it continued, of course, we went right into it because there is no use putting blood in one end and letting it flow out the other.

Concerning transfusions, we used the indirect method, the citrated blood, with very great success. Offhand I do not recall a single instance of reaction that we had; but of course we were working under much more favorable conditions. Our tubes could be cleaned and sterilized very well.

Concerning the problem of the supply of whole blood, many of these patients had to have massive whole blood transfusions regardless of the plasma that they had had before they reached us. Plasma certainly combatted and overcame the primary shock, but those patients would sometimes reach us either in secondary shock or about to drift into it.

I think it is foolish to wait for the presence of secondary shock to make obvious the need of whole blood when you know a patient must have lost a quart or more of it before he reached you.

With that in mind, we did establish a donor pool of twenty men in the Quartermaster and Supply services in the rear. Those men were sent over to our outfit up near Hill 609 when we were working there, and every day we had twenty men giving their blood.

We also got hold of an electric refrigerator which we set up in our pharmacy tent, and set up a portable generator so we had a blood bank.

In the clearing station we were still much farther from the front than Colonel Shackelford's front was. We were as far as ten or twelve miles from the actual fighting. We had no cots, merely tents for the men to be housed in overnight, and every morning all patients were evacuated regardless of their condition. When we wished to give a transfusion we had to get one of our own medical personnel to do it. We had no laboratory equipment; in the first place, we depended upon the dog tag, which is fallable. We checked that up with a gross cross-matching on a slide.

## THORACIC INJURIES\*

JOHN ALEXANDER, M.D.

ANN ARBOR, MICHIGAN

**O**NLY those thoracic wounds that involve the pleural cavity will be discussed and not those that kill so soon that practically no medical aid can be given.

Some wounds of the chest obviously are extensive and expose the lung and pericardium or other intrathoracic organs. Many, however, are so small that they have an innocent appearance and there may be little external leakage of blood. The importance of this is that in these same patients there may be very great hemorrhage into the pleural cavity, with resulting gradual collapse of the lung on the injured side; as the blood accumulates, a gradual displacement of the mediastinum occurs toward the opposite side, with consequent progressive collapse of the opposite lung. When both lungs are greatly collapsed and the great vessels of the mediastinum are severely pressed upon or kinked, fatal anoxia occurs.

I have just mentioned pressure by blood. Equally important is pressure by air, especially if the air is trapped in the pleural cavity by a wound of the thoracic wall that is so narrow and oblique that the air can not readily escape.

The air may enter the pleural cavity through a wound in the chest or through a wound in the lung, or both. The important thing about such thoracic wounds, especially those with small wounds of entrance in the case of penetrating wounds, or of entrance and exit in the case of perforating wounds, is that at first they appear to be innocent. In the last war little was known about the abnormal physiology of the condition and, therefore, little was done to correct it, and death often occurred. In this war many surgeons have been so well trained that the mortality rate from physiologic upsets of this particular type of wound has been greatly reduced in those patients who are reached by medical aid in time.

Besides those patients having relatively small wounds of entrance, or entrance and exit, such as those produced by bullets or small shell fragments, there is the other type in which there is a large opening of the thoracic wall, so large that air cannot become trapped in the

\* From the Department of Surgery, University Hospital, Ann Arbor, Michigan.

pleural cavity but enters and leaves it with approximately equal freedom. This is termed an open sucking wound. If the pleural cavity has not been previously obliterated by adhesions from pneumonia, empyema or some other condition in civilian life, the lung collapses as air rushes in; also, the mediastinum swings toward the opposite side, in which negative pressure still exists, and the lung on that side partially collapses. The lung on the side of the wide opening in the thoracic wall tends to collapse most during the inspiratory expansion of the other lung while, in expiration, the reverse takes place. Air within the lungs is, therefore, shunted back and forth, from one lung to another, and this air rapidly becomes stale air that does not contribute to oxygenation of the blood. Thus, only a part of the force of inspiration is effective in drawing fresh air down through the mouth and trachea and into the bronchi to oxygenate the blood. The mechanism described in this paragraph explains how open sucking wounds may bring about a fatal anoxia, whereas blood or air accumulating in the pleural cavity under increasing pressure brings about anoxia through great bilateral pulmonary collapse and direct pressure upon the heart and great vessels.

The patients of both groups go into apparently typical surgical shock, whether or not there is extensive hemorrhage into the pleural cavity or loss of blood through the wound in the thoracic wall. The causes of this shock are only partly due to the loss of blood (if much blood has been lost) and to the various other factors that customarily produce surgical shock.

In many cases the greater part of the shock picture is due to a special "thoracic shock." This is caused by a specific imbalance of the vital functions of respiration and circulation within the chest. These thoracic factors in the shock picture, which if untreated, are often fatal, usually can be easily relieved by expert and early care.

I cared for many French and American soldiers with thoracic wounds in the last war. The problem of the relief of gravely disarranged intrathoracic physiology was little understood and my patients showed little evidence of having been treated properly, according to modern standards. Those who reached the base hospitals apparently had survived in spite of the unfavorable conditions or because the unfavorable conditions were not grave enough to kill.

In order further to define this condition of "thoracic shock," one may speak of static and dynamic situations. The former is

illustrated by a case in which a certain amount of blood or air, or both, has entered the pleural cavity, collapsing one lung, displacing the mediastinum toward the other side but not sufficiently collapsing the opposite lung to produce a fatal anoxia by the time the hemorrhage stopped. The most frequent way in which the entrance of either blood or air into the pleural cavity is checked is by collapse of the lung containing the leaking blood vessel or bronchus; the pulmonary collapse is brought about by the accumulation of blood or air in the pleural cavity. The loss of blood or air from the lung, therefore, tends to be self-limiting. Whether or not the patient can withstand the intrapleural pressure that finally occurs will, of course, largely depend upon how great that pressure has become.

Open sucking wounds of the chest are the best illustration of a dynamic disturbance of thoracic physiology produced by a war injury. Another illustration is given by the so-called "stove-in" chest in which each of several ribs has been fractured in two or more places and in which the fragments move paradoxically with regard to the respiratory movements, namely, inward during inspiration and outward during expiration.

With regard to the management of the types of injury, perhaps the most important thing is the recognition of the potential seriousness of the situation at a time when the wound may appear innocent and when the patient's condition is good. The distant transportation of a patient who is on the edge of cardiorespiratory decompensation is likely to be fatal if competent care cannot be given during the trip. The danger is especially great if transportation is by airplane and particularly is this so if he should be transported at a sufficient altitude to cause a considerable expansion of a large amount of pneumothorax air within a closed or virtually closed pleural cavity, since the increase in the volume of the air might be enough to produce sufficient pressure on the lung and mediastinum to bring about fatal anoxia. Air trapped in the peritoneal cavity or within the gut or pleural cavity and having no means of escape, expands according to a definite mathematical formula, depending upon the amount of elevation above sea level, and may produce great pressure upon the surrounding organs, which would not occur at ground level.

As to the management of patients having surgical and thoracic shock, the usual measures employed for surgical shock are employed in these patients, as well as the special measures later to be described.

The giving of oxygen is even more important than in non-thoracic cases, because of the direct involvement of the respiratory system.

*Diagnostic Signs and Symptoms.* A simple physical examination will tell whether there is a tension pneumothorax; there should be absence of breath sounds, displacement of the heart and trachea and, perhaps, dulness over the dependent portion of the pleural cavity, denoting blood. Other signs of this condition are respiratory distress, cyanosis, rapid pulse and irritative cough. If the wound through the thoracic wall is oblique and of the incised type without loss of substance (as may be produced by bullets, small shell fragments or knives), allowing air to enter the pleural cavity more freely than it can escape, a tension pneumothorax results. In such cases, the inspiratory contraction of the muscles surrounding the wound opens the wound to the ingress of air, and relaxation of the wound in expiration tends to trap the air that has been aspirated into the pleural cavity. Similarly, certain wounds of the lung permit the escape of air into the pleural cavity during the act of inspiration and prevent the return of the air into the bronchial tree during expiration when the lung and its wound edges collapse.

If the tension pneumothorax was caused by a valvular wound of the thoracic wall, the wound should be plugged or tightly strapped as a first-aid measure and then the air that had accumulated in the pleural cavity should be promptly aspirated in order to cause the collapsed lung to expand and share in respiratory function.

One should be prepared to aspirate the air repeatedly, because, as I have said, the air may have entered the pleural cavity not only through a wound in the thoracic wall but also through a wound in the lung. The plugging of the wound in the thoracic wall will not in itself prevent the continuing enlargement of the pneumothorax through a wound of a bronchus if this should be present. Failure to aspirate as often as necessary is an important cause of death in this particular group of patients. If a patient must be transported without facilities for aspiration en route, a catheter should be introduced obliquely through the thoracic wall into the pneumothorax, and the outer end of the catheter extended so as to lie beneath sterile water in a jar placed dependently with respect to the patient's chest.

As soon as adequate operation room facilities are available, the tight pack in the wound should be removed, preferably during positive pressure anesthesia, the wound débrided and sutured air-

tight and any pneumothorax air aspirated. The patient should be urged to cough in order to keep open the airways, as many patients have injuries of the lung and retained blood and secretions in the bronchi. If necessary, postural drainage and intrabronchial aspiration by catheter or bronchoscope should be used.

When the damage to the thoracic wall or lung, or both, has been extensive, the chance of severe infection of the pleural cavity is lessened if the pleural cavity is drained dependently by the water-seal method *at the time* the wound of the thoracic wall is débrided and sutured. Drainage should not, of course, be used unless injured pulmonary vessels are sealed.

In the early part of this war there were, and still may be, some enthusiasts who urged early major exploratory operation through a long incision to remove foreign bodies and blood clots and to suture the lung or resect a damaged part of it. Experience has shown that this is unwise and leads to poor end results, including a higher mortality rate, as compared with the conservative measures I have described, namely, débridement and layer-by-layer suture of the wound, and dependent water-seal drainage of the pleural cavity to take care of potential infection and of a continued leakage of air from the lung. The conservative management gives the patient an opportunity to adjust derangements of his cardiorespiratory physiology which an early major operation might greatly accentuate.

Early, wide thoracotomy is, of course, indicated under certain circumstances, which include thoraco-abdominal wounds, continuing severe hemorrhage from the thoracic wall, lung or mediastinum and, perhaps, large retained foreign bodies. Prerequisites for such an operation should be a surgeon experienced in thoracic surgery, good positive pressure anesthesia, adequate instruments and a clear idea, on the part of the surgeon, of what he expects to be able to accomplish.

If foreign bodies, whether large or small, have not been removed from the lung, pleura, mediastinum or muscles within the first three or four days after injury and if serious infection has already developed, they should not be removed until several weeks or months have passed and until normal physiological conditions of the chest have been re-established, and preferably not until infection has been controlled.

The management of hemothorax deserves special attention. Most of the blood may enter the pleural cavity from the wound of

the thoracic wall; if the hemorrhage from this source is large, an intercostal or internal mammary or other vessel may require ligation. The most frequent source of a large hemothorax is, however, a wound of a pulmonary vessel. Mention has already been made of the self-limiting character of such pulmonary bleeding. The blood accumulating in the pleural cavity collapses the lung and thereby compresses the bleeding vessel which, being in the pulmonary circuit, has a blood pressure that is only one-fifth that of the systemic circulation.

If an exceptionally large accumulation of blood should occur before a pulmonary vessel becomes closed, the hydrostatic pressure of the blood against the heart and great vessels of the mediastinum, as well as mediastinal displacement, may produce cardiorespiratory decompensation. In such circumstances, the hydrostatic pressure must be relieved but the collapse of the lung must be maintained for the few days necessary to permit the formation of a firm thrombus in the injured vessel. This may be accomplished by the aspiration of 200 or 300 cc. of blood and the immediate injection of approximately the same amount of air, or a less amount. This sequence of aspiration and injection should be repeated until the ill effects of the hydrostatic pressure have been relieved.

Air replacement of hemothorax blood should not be used in situations other than that outlined in the last paragraph because the air rises to the top of the pleural cavity where it prevents the desirable early expansion of the lung and its adherence to the thoracic wall. If infection should be present in the pleural cavity, the injection of air would push away the lung from the uppermost thoracic wall (if the hemothorax had not been sufficiently large to do so) with resulting infection of the upper, as well as the lower, pleural cavity. An infected superior pneumothorax is usually difficult to obliterate. If an infected hemothorax is treated by aspiration and later tube drainage, without air injection, as civilian empyemas are treated, the uppermost lung quickly becomes adherent to the thoracic wall, and the lower part of the lung which was collapsed by the empyema pus gradually becomes expanded and adherent, from above downward, until no open pleural space remains to harbor pus and pyogenic organisms. These are the reasons why the often recommended routine of air replacement of hemothorax blood is likely to be harmful and to result in prolonged disability.

Three, four, or five days after the formation of a traumatic hemothorax, there is little danger that the thrombosed pulmonary vessel will bleed again if the blood is gradually aspirated and the lung thereby expanded during a period of several days. In many cases the hemothorax can thus be completely evacuated, because blood in the pleural cavity tends to remain fluid. If, however, the pleural cavity is exposed to a broad area of traumatized thoracic wall or lung, the blood is likely to clot and, then, only pockets of serum can be aspirated. Also, if a hemothorax is infected, masses of fibrin and pus cells permit only partial aspiration of the contents of the pleural cavity. Organization of blood sediment or clots or the débris of an infected hemothorax results in a mass of contracting scar tissue which holds the lung rigidly, restricting respiration and pulling in the ribs. Such patients become "thoracic cripples," being dyspneic on exertion and suffering pain because of the strong pull of scar tissue on the thoracic wall and diaphragm. Furthermore, a chronic empyema, with thick walls of scar tissue, is difficult to cure. The sequelae of unaspirated hemothorax are, perhaps, the most important cause of prolonged disability among the wounded men who have been sent to the base hospitals in this country with thoracic wounds.

The characteristics of hemothorax just described make clear the importance of early, staged aspiration of all fluid blood that can be withdrawn. Even when no infection is present, delay in aspiration may result if the partial sedimentation and subsequent organization of that part of the hemothorax blood that does not become absorbed. We should, therefore, reject the advice often given that hemothorax blood should be aspirated only when it is producing pressure symptoms.

In cases in which clotted blood or an infected hemothorax prevents emptying of the pleural cavity by aspiration, there is an increasing tendency among the thoracic surgeons who see the patients within a month or six weeks after they have been wounded, to open the chest and manually to remove the masses of organizing blood clot and débris. The operation may include the stripping of a layer of organizing material from the visceral pleura so that the lung will be able to expand; this procedure is termed pulmonary decortication.

The therapeutic results of thoracic injuries in this war are remarkably good and are infinitely better than they were in the last

war. During the last war I spent most of my time removing shell fragments from muscles and lungs and combating pleural and pulmonary infection which was almost always present. The knowledge thoracic surgeons acquired from the thoracic wounds of the first World War and from experience in civilian thoracic surgery conditions during the following years has led to measures that often effectively correct disturbances of thoracic physiology and that bring about early complete expansion of a collapsed lung, which is probably the most important factor in preventing prolonged disability from infection of the pleural cavity.

#### DISCUSSION

CASPER P. HEGNER (Denver, Colo.): Dr. Alexander is not only a pioneer but he is the man who has stimulated and trained more men in doing thoracic surgery than any other person in the United States.

He has well said that the thing peculiar to thoracic injuries is due to the small margin of safety under which the thoracic viscera function. We, therefore, have disturbances of the physics and physiology of the intrathoracic viscera, particularly the lungs, also the heart and the circulating blood. If a surgeon attempts to do anything in the treatment of these injuries, he must remember the peculiar conditions presented only by the intrathoracic viscera.

Dr. Alexander emphasized the point that the external evidence of injury is no index to the severity of the internal damage. Therefore, one should not attempt any definitive treatment unless environment, facilities and personnel are qualified to meet every contingency that might arise.

We see that not only in hospital practice but in our part of the country where we have people who, injured by automobiles, have crushing injuries of the chest, with pneumothorax and hemothorax. These patients are delayed in being brought to the hospital for their definitive treatment, and the individual who first saw the patient either attempted too much or did too little.

The question about pneumothorax is an important one. We know we have a closed type which may be simple, and not disturb the patient very much. But if it is recognized by the surgeon and he attempts to do something to that, he may contaminate and infect the patient.

The pneumothorax must not be disturbed unless it produces definite dyspnea, respiratory or circulatory distress. In the type of tension pneumothorax which increases in magnitude and pressure with each respiration, it must be relieved on the spot.

I would offer a suggestion more efficient than repeated needle aspiration, that is, insert only a hypodermic needle and relieve the pressure

constantly, just in proportion to the increase; if it is very great, a larger caliber needle might be introduced. If there is any fluid there, tie over the end of that needle a thumb cot or a rubber glove finger which is slitted so it can be a valve which will let the pressure out as well as facilitate drainage and not let any air in. That will take care of the tension pneumothorax that originates from the bronchial side of the injury.

In open pneumothorax the dangers increase in direct proportion to the size of the opening and the length of time it remains patent in an individual. For instance, a man had part of the side of his chest shot away by a gunshot wound while crawling through a fence. The wound was so large that you could put your two fists into it. Fortunately, he was within half an hour of the hospital and was brought in. While we were preparing to do something for him in a definitive way we covered him with a wet towel. You would be surprised how quickly he was relieved of his dyspnea.

Dr. Alexander mentioned anoxemia. That can be very rapidly fatal. We know that it can also be chronic and can cause a patient to lose ground gradually, and you will not be able to explain it. The exchange or the interchange of air from the good side into the lung of the injured side accounts for that because it does not get enough oxygen to supply the requirements of the body.

The shock accompanying these injuries is not only due to the injury itself, but it is also due to the alteration of the mechanics by which the heart cannot supply sufficient blood thoroughly oxygenated to the vital centers of the brain, and therefore that must be controlled by closing off the open wound.

The hemothorax may come from the wall vessels, intercostals, internal mammarys or the subpleural, and that is progressive and goes on and will become fatal unless it is taken care of. Those patients require operation. Those which come from parenchyma, as Dr. Alexander has well said, are controlled by the fact that the lung collapses, but it may become massive. Hemorrhage in the hemothorax should not be aspirated until and unless the respiratory distress and dyspnea become so great that you have to relieve the pressure.

It should not be aspirated for several days; and when you do aspirate it, aspirate it and replace it with air. I know this is a moot question, but it takes care of the intrathoracic tension, and air is absorbed much more rapidly than fluid.

The question of clotting of blood is a very peculiar one and is not thoroughly understood. The more slowly blood accumulates, the more likely it is to coagulate. Blood in any amount in the thoracic cavity is a nidus for infection. It supplies a splendid medium for bacteria, and it is better to aspirate (when you do) all the blood and replace it with a corresponding amount of air. This will eliminate that condition favorable to bacterial growth.

Dr. Alexander, of course, did not have sufficient time to go into all the details. We appreciate what he has said. There is much more to be said about thoracic injuries than his time permitted. The little points I have brought out I have used in civilian practice, and I know it would be much better to put in a needle than to have a bottle hanging by your side when transporting an individual from the front lines to a base hospital or to a hospital in the rear. The house staff does not appreciate that they have to reaspirate to relieve tension promptly. They may come late and will find the man almost in extremis; but if they put in the needle and cover it with a piece of gauze, this will answer very well.

**COLONEL GROVER C. PENBERTHY** (Medical Corps): Dr. Alexander has emphasized the need for the early recognition of tension pneumothorax, hemothorax and the methods to be employed in dealing with such serious complications of chest injuries.

It is important and imperative that the complications of chest injuries be recognized early as described in this presentation. The interest shown by the thoracic surgeons, combined with the surgical teams that have been organized and functioning, as explained and referred to by Colonel Shackelford, offers security from the point of view of dealing with chest injuries near the front. It is apparent that the officers have an understanding of the physiology, mechanics and pathology of chest injuries.

The chest cases that I see on rounds visiting the general and station hospitals in this country throughout the Seventh Service Command are well handled indicating that the officers have been trained in the fundamental principles of thoracic surgery. As a result, the mortality from empyema, for instance, in this war is minimum and practically nil as compared with that of World War I.

## FROSTBITE

### CLASSIFICATION AND TREATMENT

G. M. BROWNRIGG, M.D.

Assistant Surgeon, St. John's General Hospital; Surgeon, Sanatorium, St. John's  
ST. JOHN'S, NEWFOUNDLAND

**W**HEN human beings are subjected under unfavorable circumstances to temperatures below those to which the body is accustomed, frostbite results. Exposure to moderate degrees of cold for a prolonged period will produce lesions identical to those seen in persons exposed for a short period to an extreme degree of cold. The duration of exposure is as important in the production of lesions as is the degree of temperature. Thus there is a time temperature factor.

The presence of moisture, as in immersion in cold water or standing in wet trenches, is an almost equally important factor. There is ample clinical evidence that the presence of moisture hastens the onset of the lesions. Experimental evidence confirms this belief. The work of Smith, Ritchie and Dawson<sup>10</sup> proves beyond doubt that the lesions occur with less severe degrees of cold when the tissues are wet. The experiments of Lewis and Love<sup>15</sup> indicate that this is due to the phenomenon of "super cooling." Obviously, lack of or inadequacy of protective garments, is an important factor. Clinically and experimentally, there is ample evidence that constricting garments are harmful. Immobility is also an important factor.

Exposure, under unfavorable circumstances, to extreme degrees of cold for prolonged periods may lead to death before tissue reactions occur. There are numerous known cases in which the entire body has been found completely frozen. Where death does not occur before tissue reaction sets in, typical lesions develop. These lesions are identical whether frostbite is or is not accompanied by immersion, or whether it follows exposure for a relatively short period to intense degrees of cold or for a relatively long period to very moderate degrees of cold. Failure to recognize these facts has led to much confusion. Larrey,<sup>1</sup> in the Napoleonic wars, saw and recorded large numbers of cases of frostbite. They were observed and recorded in successive military campaigns. In the Balkan Wars, where men

were exposed in wet trenches to moderate degrees of cold, frostbite was prevalent. Because actual freezing temperatures did not occur, the true nature of the lesions went for a time unsuspected and infected rye bread was for a time suspected of being responsible for the occurrence of gangrene. Page<sup>8</sup> pointed out that cold was the important factor. In the first World War similar lesions were encountered in the trenches. Clinically, the lesions were identical with those classified as first degree frostbite. Because more serious lesions did not occur there was again doubt as to the real nature of the lesions; but Smith, Ritchie and Dawson<sup>10</sup> in their excellent experimental studies showed that cold was the most important factor, and recommended that they be classified as frostbite. In the present war large series of cases have been recorded following shipwreck. Clinically, all these cases would seem, from the published reports, to be identical with cases recorded in our series. The majority of the cases have come from the North Atlantic where temperatures at or near the freezing point prevail; but cases of the mild type, which would appear to be similar to our first degree cases, have occurred in the gulf stream at temperatures ranging from 50 to 70° F. It must be noted that these temperatures are far below the normal temperature of the human body, and under unfavorable conditions with lack of adequate protection, with prolonged immobility, immersion in water far below normal body temperature, and prolonged exposure, frostbite results. In the Southern United States similar lesions have been recorded<sup>31</sup> under similarly unfavorable circumstances.

Whatever may be the contributing factors the lesions of frostbite are similar in all groups of cases. Any portion of the body may be subjected to actual freezing and tissue reaction will follow, but exposure to cold, not sufficient to cause death, typically results in the occurrence of lesions in the extremities. The ears and tip of the nose are often, but much less frequently affected. We believe that lesions occur in these tissues because here the ratio of mass to surface area is least and heat loss from these tissues is consequently greatest. The lower extremities were more commonly affected in our series and here second and third degree frostbite was common. The lower extremities were in every serious case immersed in water in the open lifeboats. The upper extremities, in a considerable number of cases, showed first degree frostbite although these extremities were not immersed.

In a previous communication<sup>32</sup> we have presented a study of seventy-one cases seen in shipwrecked mariners. Since then additional cases have been seen bringing the total number of cases to ninety-eight. A few of the later cases were in patients in whom no immersion occurred. Clinically, the cases were essentially similar. Our observation of these cases obviously led to the conclusion that they fell into three broad groups—the mild, the moderate and the most severe—and suggested a classification into first, second and third degree frostbite depending upon the severity of the lesions. The essential features of the three groups are summarized in the accompanying table (Table 1):

TABLE I

Degree	Local Condition	Constitutional Reactions	End Result
First . . .	Swelling of affected extremity with pain, redness and increased temperature; in more severe cases bleb formation	Slight; fever of 99 to 100°F. common; subsides rapidly	In less severe cases restoration to integrity of parts with no disability; in most serious cases prolonged disability with stiffness of affected parts and persisting pain; no tissue loss
Second . . .	In addition to those above dry gangrene of the most distal portions of extremity; in mild cases, of terminal phalanges only; in more severe, of digits and in most severe of more distal parts of foot or hand	As above	Loss of digits or of distal portions of foot or hand
Third . . .	In addition to lesions proper to degrees to 1 and 2 extensive gangrene involving more proximal portions of extremity, often of incomplete or wet type, extending in the lower extremity above the ankle to the knee or even to the thigh	Severe prostration; high fever	Loss of limb

## PATHOLOGY OF FROSTBITE

Since frostbite in the human patient results either in restoration to integrity of the tissues affected or to the complete death of the

tissues, with or without the complication of infection, pathological material from this source is of little value in arriving at any understanding of the mechanism by which the tissues are destroyed. Gangrene whether caused by cold, by other trauma, or by primary disease of the vascular system is essentially the same process—death of tissue. Thus, Brahdy, in a recent and excellent article on frostbite, gives an account of the pathological changes observed in tissues removed four months after the onset of the condition. These consisted of atrophy of the skin, necrosis of bone, production of granulation tissues or fibrous tissue and the presence of organized thrombi in vessels. These studies are certainly of great interest. They do not, however, offer much that is of value when we are faced with the problem of what we should do about the treatment of these conditions. Tissues removed surgically represent the end result of the changes initiated by physical agents. They give us no insight into the early tissue changes which are of paramount importance. We must, therefore, turn to experimental pathology if we are to gain an understanding of the sequence of events when tissues are subjected to extreme or prolonged exposure to cold.

In this connection we are most fortunate. Two studies of inestimable value are available. One by Richspler<sup>3</sup> deals with the effects of freezing on animal tissues. The other by J. Lorraine Smith, Ritchie and Dawson<sup>10</sup> studies the effects of moderate but prolonged exposure to cold and wet upon animal tissues. The first study closely reproduces the conditions under which humans experience has been considered as true frostbite; the second study reproduced the conditions observed in successive military campaigns, and which during the first world war was christened "trench foot," but which we now have seen in shipwrecked mariners far removed from the comparative security of trench warfare.

Richspler<sup>3</sup> subjected animal tissues to freezing by a mixture of ice and salt and observed the tissue changes after varying periods of exposure. He found that all of the phenomena observed were due to inflammation caused by cold. Early edema resulted; the bundles of connective tissue were swollen; the muscle fibers of the vessel walls showed early vacuolation; the changes in the nerve fibers were not marked and were not constant; there was little or no evidence of thrombosis in the vessels.

Richspler was compelled to conclude that the formation of thrombus was secondary to inflammatory changes in the vessel

walls and that no significant changes in nerve tissues could be observed. Here then is a compelling similarity to the pathological changes observed by a second group, namely, working on tissues subjected to cold under dissimilar conditions, but under conditions exactly simulating those encountered both in trench warfare and in our group of cases among shipwrecked mariners. (J. Lorraine Smith, Ritchie, and Dawson<sup>9,10</sup> give an account of their observations on soldiers invalidated from France suffering from trench foot and of experimental studies on rabbits subjected to exposure to moderate cold and standing in mud of varying degrees of moisture. By this means they were able to reproduce in the shaven extremities of rabbits lesions identical to those observed by them in soldiers. Their experiments were conducted in the laboratories of the Royal College of Physicians in Edinburgh upon the request of the National Insurance Medical Research Committee and arose out of the prevalence of frostbite among the members of the British Expeditionary force to France during the winter of 1914-1915.

I shall not attempt to give in detail the experiments carried out nor the detailed histological findings in the tissues studied. It is necessary, however, if we are to gain an understanding of the nature of frostbite to review briefly their more important findings.

The temperature of the chamber in which the experiments were conducted was about 0°c. They definitely established that moisture hastened the onset of damage to the tissues. They also were able to show that constriction of the extremity hastened the onset of tissue changes. Interestingly enough, anesthesia developed early in the tissues as evidenced by absence of the pinch reflex.

Grossly, the tissues responded by edema. Sections of tissues obtained soon after the development of edema showed no changes in the larger vessels. The smaller arteries and veins and the capillaries showed enlargement of the endothelial cells of the intima and infiltration of the perivascular tissues with polymorphonuclear and mononuclear cells. In the neighborhood of the vessels the connective tissue cells were swollen. Generally, the connective tissues showed edema with plentiful deposition of fibrin most marked beneath the skin papillae. No hemorrhage was observed in the connective tissues. In the epithelial tissues perinuclear vacuolation with some mitosis in the cells of the germinal layer was seen. Nerve tissues showed no change. A few isolated staphylococci were noted in the subepithelial connective tissues. Sections of the popliteal glands also showed

changes, notably dilatation of the central sinuses with marked separation of enlarged follicles. In the spaces free cells, some showing marked phagocytosis, were present.

Generally speaking, the tissue changes observed showed essentially these features in varying degrees. The more prolonged the exposure, the more marked the changes. Exposure to wet mud as contrasted with dry mud resulted in earlier and more marked changes but to no significant difference in the type of tissue reaction.

Notably absent was thrombosis of the vessels, vasoconstriction, or significant changes in the nerves. More prolonged exposure resulted in some edema of nerve tissues, to deposition of fibrin, and also to an increase in the number of micro-organisms, staphylococci and streptococci, noted.

Tissues subjected to heat, and tissues subjected to constriction showed in addition extravasation of red blood cells into the edematous tissues, and in some cases actual hemorrhage. The authors concluded that this was due to the damaged vessels giving way under the strain of additional trauma.

Brahdy<sup>18</sup> described the findings in tissues removed several months after the development of the lesions seen in ordinary frostbite in civil practise. These tissues showed atrophy of the skin, necrosis of bone, the presence of large amounts of granulation and fibrous tissue and thrombosis in the vessels.

Tissues taken many months after the development of the lesions from cases in our group of shipwrecked mariners were strikingly similar. The most striking feature was the presence of a large amount of fibrous tissue throughout the sections; inflammatory cells were still present but scar tissue was predominant. The blood vessels showed marked thickening with endarteritic changes of a productive nature narrowing the lumen. Even the marrow spaces of the bone showed a marked deposition of fibrous tissue and many of them were filled completely with it. Careful study revealed no changes in the nerves. It is obvious that the pathological changes in tissues removed from patients seen clinically represent the end results of a process similar to that recorded as occurring in experimental animals.

It will thus be seen that we can reconstruct in some measure at least, from the data available, the sequence of events in tissues damaged by cold. The essential feature of the reaction in the tissues is its inflammatory nature. All tissues affected respond in a similar fashion. From the beginning there is a notable tendency to deposit

fibrin and later an enormous amount of scar tissue is the result. Damaged vessels respond by inflammatory changes in the vessel walls and in the later sections we see the end result of this inflammation.

The animals utilized by Smith, Ritchie and Dawson recovered rapidly when removed from the cold chamber in which the experiments were conducted. Clinically, by far the greater number of cases seen by us in our group of shipwrecked mariners recovered without apparent permanent disability although there were, unfortunately, many exceptions to this rule. Thus the changes in the tissues are up to a certain point reversible. Where exposure is prolonged, tissue reaction is of such a degree that restoration to integrity is no longer possible and permanent tissue changes or loss of tissue results.

#### TREATMENT

Larrey<sup>1</sup> first recorded the harmful effects of the application of heat to tissues damaged by cold and noted the frequent onset of gangrene in tissues so treated. Smith, Ritchie and Dawson<sup>10</sup> have shown experimentally that rapid warming of the affected parts greatly aggravates the condition and this was confirmed by Lewis and Love.<sup>15</sup> Greene<sup>20</sup> has shown that if the tail of a mouse is frozen, the tissue loss is twice as great if the mouse is held before a warm fire. There is thus ample clinical and experimental evidence against the use of heat locally.

In first degree frostbite the affected extremities are, during the stage of reaction, hot to the touch and in second and third degree frostbite the areas above the level of complete, or dry, gangrene are also hot to the touch. Skin temperature readings on these parts are uniformly several degrees higher than those of the affected extremities. From the pathological data available it is obvious that we are dealing with an inflammatory reaction.

In an effort to control the blood supply to the affected limbs and thus to minimize tissue reaction Lake<sup>13</sup> suggested the use of vasoconstrictor drugs but was not impressed with the results. Lewis and Love<sup>15</sup> suggested the use of a tourniquet with the same object in view. It would seem from the work of Smith, Ritchie and Dawson that this latter might be productive of more harm than good.

The application of cold to frostbitten parts is traditional. Recently, it has been endorsed by Webster, Woolhouse and Johnston<sup>27</sup> and suggested by Greene.<sup>30</sup> On theoretical grounds there is ample justification for its use. Cooling would both decrease the blood

supply to the affected part and, by reducing the metabolic processes in damaged tissues lessen the oxygen requirements and so result in a decreased demand.

Webster, Woolhouse and Johnston<sup>27</sup> have reported dramatic improvement in patients treated by refrigeration. They employed fans blowing a current of air, chilled by ice trays, over the damaged extremities.

Greene<sup>28</sup> has devised an ingenious cabinet with one compartment for the damaged extremities and a second for the refrigerant, solid carbon dioxide. The cabinet is provided with adequate controls for regulating the temperature of the therapeutic compartment. Greene had not had an opportunity of testing this device when the communication describing it was published. He suggested that its efficacy should be tested for a time by treating one limb only of a bilaterally affected limb and using the opposite limb as a control.

The majority of the patients in our series were not treated by refrigeration but the limbs were elevated and exposed to room temperature, covered only with sterile towels and in the majority of cases protected from infection by mild skin antiseptics or a dusting powder containing one of the sulfa drugs. In none of these patients was there any extension of existing gangrene and in none did gangrene occur if it were not present upon admission.

In a small group of cases occurring late in the series refrigeration by means of ice bags was employed. In bilateral cases ice bags were applied only to one limb, the other being left exposed at room temperature. We could see no appreciable difference resulting from the application of ice bags and the patients did not notice any improvement subjectively in the cooled limb nor were they always perceptibly co-operative in keeping their extremities in contact with the ice bags provided.

It must be emphasized that these findings are not regarded as conclusive for the series was small and some of them were aboard rescue ships several days before reaching the hospital for treatment, so that some of the tissue reaction might reasonably be supposed to have subsided. They do indicate, however, that unreserved acceptance should not be given to this method of treatment and that its cautious application under carefully controlled conditions may help to determine its true importance.

Because of the risk of additional trauma to the tissues massage should be avoided in the early treatment of frostbite. Greene<sup>28</sup> also

advises against the use of the Pavex boot in this stage of the disease. With this opinion there can be no disagreement.

Miscall<sup>21</sup> suggested the use of paravertebral sympathetic block and it has been employed by Penberthy.<sup>33</sup>

There is every evidence that in the stage of reaction, when there is increased heat in the tissues clinically, anything which might increase this reaction should be avoided. Its use in early cases would, therefore, seem to be positively contraindicated.

This led us to wonder if there might be some justification for its use later on when the primary inflammatory reaction had subsided. Here its use might reasonably be justified by the hope that it would hasten healing of tissues in proximity to areas of gangrene. We, therefore, decided to try the effect of spinal anesthesia on skin temperatures as measured by the thermocouple in cases of second degree frostbite. Several patients were treated in this manner. The results obtained in two such cases are shown in Table II.

One was a case of frostbite in a rescued seaman in whom immersion had been a factor, the other a young man suffering from second degree frostbite as a result of exposure for several days when he went astray while on a hunting expedition.

The result in each case was the same. There was no appreciable difference in skin temperatures following the administration of a spinal anesthetic. We, therefore, concluded that the use of sympathectomy would be of no value.

In second degree frostbite in which dry gangrene is present amputation should not be practised. The formation of an apparent line of demarcation is deceptive. Superficially, the area of gangrene is always much more extensive than is the gangrene in the deeper tissues. One patient in our series showed a line of demarcation in one foot extending to just below the malleoli on the plantar aspect of the foot and to the mid-metatarsal region on the dorsal aspect. Spontaneous separation was permitted. The final result was loss of the toes only and a few skin grafts over the heads of the metatarsals were all that was required to complete healing. This observation is not original. It has been strongly stressed by Rabut,<sup>22</sup> Greene<sup>24</sup> and Thompson;<sup>26</sup> yet in spite of their warnings many limbs have been needlessly sacrificed because of the existence of a traditional "line of demarcation." This type of gangrene presents no threat to the welfare of the patient and there is no justification for early amputation. It is my belief that there is no justification for surgical

TABLE II

T. M. age 18, Second degree frostbite

Room Temperature 70°F.; body 98°F. (oral)

Time before spinal—Extremities exposed 60 minutes at room temperature prior to beginning of readings

Time	Thermos Temp.	Volt. Read.		Extremity Temp.	
		L.	R.	L.	R.
0.10	28.5	-3.5	-3.25	32.	31.75
0.15	28.35	-3	-3	31.35	31.35
0.20	28.35	-3	-2.5	31.35	30.35
0.25	28.3	-2.75	-2.5	31.05	30.8
0.35		Spinal 100 mg. novocaine			
0.40	28.2	-0.75	-0.5	28.95	28.7
0.45	28.2	-1.0	-2.0	29.2	30.2
0.46	28.1	-2.25	-2.5	30.35	30.6
0.48	28.1	-2.25	-2.5	30.85	30.35
0.52	28.1	-2.75	-2.0	30.85	30.1
1.00	28.	-2.2	-1.7	30.2	29.7
1.05	28.	-1.7	-1.7	29.7	29.7
1.10	27.4	-2.7	-2.0	29.7	29.4
1.15	27.4	-3.0	-2.0	30.4	29.4

F. R. Y., Second degree frostbite

Room Temperature 70°F.; body 98°F. (oral)

Time before spinal—Extremities exposed 45 minutes at room temperature prior to beginning of readings

Time	Thermos Temp.	Volt. Read.		Extremity Temp.	
		R.	L.	R.	L.
10.35	26.3	-3.25	-3.25	29.55	29.55
10.40	26.3	-3.5	-3.25	29.8	29.8
10.45	26.3	-3.25	-3.25	29.55	29.55
10.50		Spinal 100 mg. novocaine.			
10.55	26.2	-3.25	-3.12	29.45	29.32
11.05	26.2	-3.25	-3.12	29.45	29.32
11.15	26.1	-3.25	-3.5	29.6	29.6
11.25	26	-4	-3.5	30.	29.5
11.40	27.4	-2.5	-3	29.5	30.5
11.45	27.4	-2.5	-2	29.9	29.4
11.50	27.4	-2.5	-2	29.9	29.4
12.00	27.3	-2.5	-2	29.9	29.4

interference whatever beyond the removal or trimming of necrotic bone when spontaneous separation has occurred and the judicious use of skin grafts where necessary.

In third degree frostbite wet gangrene is present extending above the ankle and in severe cases above the knee. These cases are gravely ill and the limb must be sacrificed to save life. They differ from first and second degree cases in one important aspect. They appear extremely toxic and have a high temperature which does not subside when treatment is instituted. Although patients with first and second degree frostbite show rapid improvement in their general condition, these patients deteriorate from day to day. The real nature of their condition soon becomes apparent. The larger tissue masses of the leg have been damaged beyond recovery and a "wet" or incomplete gangrene is present. Saprophytic infection contributes to the toxicity and is present even before any break in the skin is manifest.

While these cases may be difficult to recognize, when first seen the presence of a high fever is significant in the absence of intercurrent infection. They are soon recognized, however, and as soon as the patient's condition permits amputation must be performed. If the gangrene is of the wet type, prosthesis should not be taken into account at this stage but guillotine amputation is not necessary and the cutting of flaps is permissible if feasible. In those cases in our series in which flaps were cut and closure practised the patients did uniformly well. This is in keeping with the observation that we are dealing here, not with infection, but with incomplete gangrene.

In those cases of frostbite in which dry gangrene extends into the denser tissues of the leg there might be some justification for classification of these cases as fourth degree frostbite. Since loss of limb would be the result in these patients, we believe that for statistical purposes they can best be classified as third degree. In such cases amputation could be performed leisurely and prosthesis would be the guiding factor as to site of amputation.

#### CONCLUSIONS

1. All lesions resulting from exposure to cold are essentially similar. The term "frostbite" is adequate to describe them regardless of the circumstances under which they occur.
2. A clinical classification of frostbite depending upon degree of severity is proposed.
3. The use of heat is harmful; the use of refrigeration may be of value in dealing with these lesions but requires further study.

4. The use of sympathectomy is contraindicated in early treatment and cannot be shown to be of value in late treatment.

5. When dry gangrene is present, the "line of demarcation" is deceptive; avoid amputation; allow spontaneous separation.

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# AN ADDITIONAL REPORT ON SOME OF THE USES OF CUTIS GRAFT MATERIAL IN REPARATIVE SURGERY\*

JOHN E. CANNADAY, M.D.

CHARLESTON, WEST VIRGINIA

**I**N 1939, the report of Uihlein<sup>1</sup> concerning Rehn's<sup>2</sup> work with cutis (derma) in surgical repair procedures was brought to my attention and I decided to make use of the method. Our first operative use of cutis was in July, 1940, at which time Dr. Bankhead Banks and I repaired a very large epigastric hernia. A very satisfactory result ensued. Since that time we have gradually found increasing indications for the use of the method.

At the December, 1941, meeting of the Southern Surgical Association, I presented a review of the literature on the subject and reported the successful use of the method in fourteen cases. In the cases reported at that time were six large incisional hernias, five direct inguinal hernias in which the structures were defective, one fracture of the patella, one on-lay bone graft for non-union, one suspension of the cervix in a case of prolapse of the uterus—all with primary healing and apparent good results.

At the Boston meeting of The American Association for the Surgery of Trauma, June 4, 1942, a further report of cases in which cutis grafts had been used was made, bringing the total number of cases to thirty-seven.

At the Chicago meeting of the previously mentioned Association, June 9, 1944, a total of eighty-six cases in which cutis had been used was reported.

The use of the cutis graft has been rather generally recognized by the plastic surgeons and more especially by Peer<sup>3</sup> and Paddock, Smith,<sup>4</sup> Ivy<sup>5</sup> and others. Recently, a report of its successful use in the repair of an abdominal incisional hernia has been made by Swenson<sup>6</sup> and Harkins, of the Henry Ford Hospital.

*Indications.* Cutis transplants may be used to take the place of fascia lata whenever and wherever indicated and to give more satisfactory results, e.g., to repair or reinforce defects in aponeurotic

\* From the Surgical Department of the Charleston General Hospital, Charleston, West Virginia.



FIG. 1. Ankylosis of jaw before operation.



FIG. 2. Ankylosis of jaw after cutis graft repair.

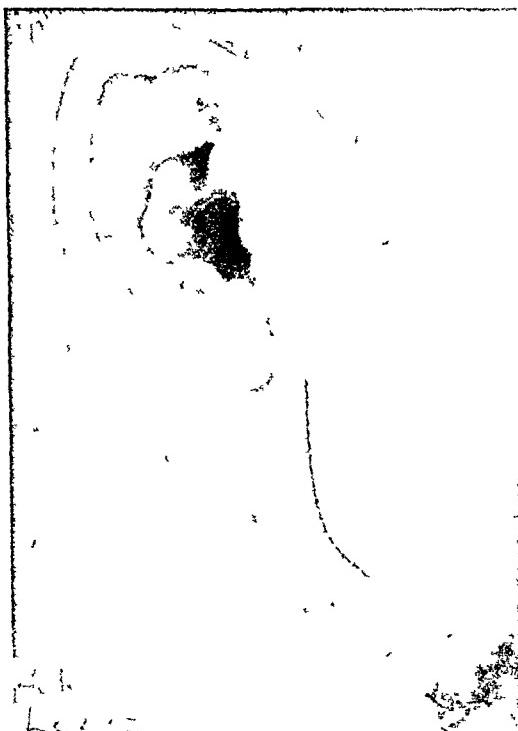


FIG. 3. Ankylosis of jaw; outline of incision for operation.

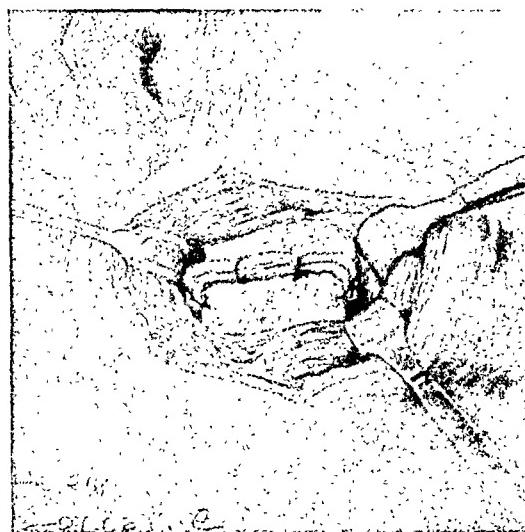


FIG. 4. Ankylosis of jaw; operation showing double thickness cutis graft in place.



FIG. 5. Large incisional abdominal hernia previous to operation.

FIG. 6. Large incisional abdominal hernia after cutis graft repair.

structures, to replace destroyed dura, to reinforce or replace external and internal ligaments of the knee or other joints, to restore the lining of joints, for interposition between fractured long bones for



FIG. 7. Closure of subcutaneous fat when cutis graft is used.

the prevention of synostosis, to reinforce the walls of aneurysms in case of impending rupture,<sup>7</sup> to restore normal contour to the nose, lips and face,<sup>8,9</sup> in the stage ligation of blood vessels, for autoplastic sutures, and as a support for the bowel in colostomy. Cutis, along with a layer of fat and aponeurotic tissue, has been used by Berson<sup>10</sup> for the filling out of defects of body contour such as after the resection of all or a portion of the breast, the reinforcement of the aponeurosis of abdominal muscles that have lost their tone from local paralysis such as at times may follow poliomyelitis,<sup>11</sup> to correct diastasis of the buccinator muscle developing in glass blowers and at times in musicians who blow horns.

*Technic.* The present technic is as follows: The skin is prepared with iodine followed by alcohol. A thin layer of skin is usually removed with a skin graft knife or, if only a strip of cutis is to be

used for suture or ligature purposes, the epidermis can be readily removed with a Durham Duplex safety razor blade. The antero-external surface of the thigh is usually the favorite donor site. If

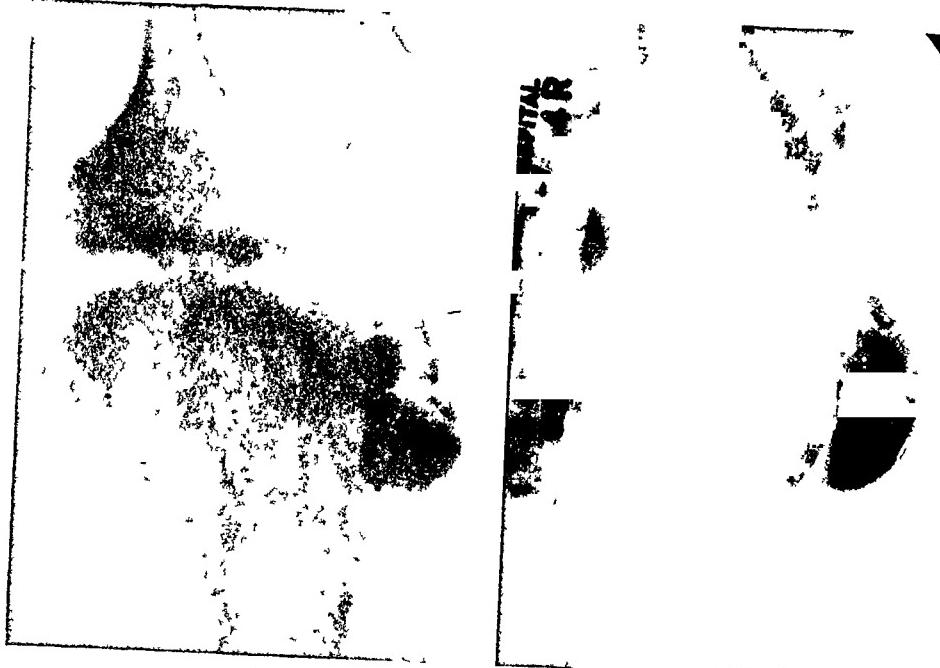


FIG 8 A, multiple fracture of patella before operation, B, fracture of patella after cutis graft repair.

the raw area left is not too wide, the skin edges can be readily approximated; or if a large graft has been taken, the epidermal layer can be used as a skin graft to cover the raw area. The graft is sutured into position under firm tension with No. 30 or No. 40 interrupted cotton thread sutures spaced rather close together. The wound is irrigated with normal saline solution. A moderate amount of sulfanilamide is placed in the wound, at times a little crystalline sulfathiazole also. The subcutaneous fat is accurately sutured over and down to the center of the implanted dermal graft with No. 70, 80, or 100 interrupted cotton thread sutures, the needle bite picking up a portion of the center of the graft with each suture. In case the patient is very obese a second layer of sutures is placed in the fat. All dead space is carefully eliminated, no drains are used, a moderate pressure dressing of mechanic's waste is applied over the wound and is kept in place for about ten days. These patients are gotten out of bed daily beginning on the day following operation.

## CASE REPORTS

CASE I. R. B., a white male, age twenty, was admitted to the hospital July 13, 1942, with a compound depressed fracture of the left parietal region. There was a deep laceration of the left parietal region. X-ray examination indicated that a portion of the depressed bone had been driven into the brain for the depth of about one inch.

Operation was performed soon after admission, by the surgical resident, Dr. Victor Skaff. The traumatic incision was débrided and elongated. The depressed areas of bone were removed. A considerable amount of brain tissue escaped. The lacerated meningeal artery bled freely and was controlled by electrocoagulation. The area from which the bone was removed was about one and three-fourths inches in diameter. Since a considerable portion of the dura had been so badly lacerated that it could not be satisfactorily sutured on, a cutis graft was taken from the left thigh and sutured over the damaged area of the dura. When in place the graft covered most of the opening in the skull. The temporalis muscle was sutured over the graft and the scalp closed with interrupted sutures in the usual manner. The patient had an uneventful convalescence and was discharged from the hospital July 24th, apparently in excellent general condition. When seen about six weeks later the area over the bony defect that had been covered by the graft was quite firm to the touch. It was apparent that the cutis graft had in considerable measure formed a protective covering over the area of brain that had been exposed.

CASE II. S. D., a colored male, age twenty-seven, was admitted to the hospital October 30, 1942, with a history of an injury to the left shoulder received in a mine accident which resulted in inability to move the shoulder in a satisfactory manner. A diagnosis of dislocation of the acromial end of the left clavicle was made.

Under ether anesthesia operation was performed November 11th, by Dr. H. A. Swart and myself. The Bunnell technic was used except that a strip of cutis was substituted for fascia lata. Although this patient was apparently in vigorous health, his heart stopped beating and he died in the operating room just after completion of the operation. Autopsy was not obtained.

CASE III. J. H., a seven year old colored female, was admitted to the hospital on June 22, 1942, with total ankylosis of the jaw, right side involvement. The upper and lower teeth were firmly fixed in rigid position with a space of about one-eighth inch between. She was unable to chew her food and was forced to subsist mainly on liquids.

At operation July 7th, the ramus of the right jaw was subperiosteally divided about midline. This procedure is readily accomplished with a slotting burr. A folded strip of cutis was implanted between the bony ends.

Following this operation the child almost immediately enjoyed full use of her jaws to the extent that she was able to open her mouth and to protrude her tongue readily. A letter from her mother on February 1, 1944, was to the effect that the patient had good use of her jaws and has had no trouble in chewing her food or in opening her mouth since her discharge from the hospital.

CASE IV. R. L., a white male, age thirty-two, was admitted to the hospital on January 19, 1943, complaining of painful herniation of buccinator muscle, right side, incidental to his occupation as glass blower.

At operation on January 20, a nearly vertical incision corresponding to the normal lines in the face, was made. The skin over the area of the diastasis was separated from the underlying structures so as to expose the principal surrounding muscular aponeuroses. A cutis graft was sutured into position over the principal area of the diastasis. The patient has been seen on two occasions since his discharge from the hospital. The cheek is considerably thickened but the pain has entirely disappeared.

CASE V. E. J., a white male, age twenty-nine, was admitted to the hospital on September 29, 1943, with a comminuted fracture of the right patella.

At operation on October 11th, a strip of cutis from the right thigh was passed through a circular tunnel made in the aponeurotic structures immediately surrounding the patella. On tightening this strip of cutis tissue it was noted that the fragments of patella were rather well approximated. The free ends of the cutis strip were overlapped and firmly sewed together with interrupted cotton thread sutures. A plaster cast was applied to thigh and leg. A window was cut in the cast over the patellar region. The wound healed by primary intention. When the cast was removed on November 26th, there was considerable motion in the knee. The patient has been checked on since and the knee motion has been found to be gradually approaching normal.

Our series of eighty-six cases to date comprises the following conditions in which cutis has been used: five epigastric hernias; nineteen abdominal incisional hernias (in one of these cases the patient did not take the anesthetic well and died shortly after completion of the operation, apparently from respiratory failure); one umbilical hernia; twenty-three direct and indirect inguinal hernias; one case of ankylosis of the jaw; one case of diastasis of the buccinator muscle (glass blower's hernia); one case of extreme diastasis of the rectus muscles; in fourteen cases to suspend the uterine cervix for the relief of prolapse; in one case to suspend the urethra for the relief of urinary incontinence; six cases of wobbling knee; three cases of fracture of the patella; one case of fracture of the ulna; in

one case for stage ligation of the common carotid artery; one case for partial occlusion of the femoral artery for the control of a popliteal aneurysm; in two cases for replacement of torn dura; to support the bowel in four cases of sigmoid colostomy; one case of luxation of the acromial end of the clavicle; and one case of marked bulging of the lower abdominal aponeurosis.

*Complications.* Complications have been few. In my personal series of fifty-seven cases there has been one hematoma, one serum pocket, three superficial infections, and one death, cause undetermined. In none of my cases has there been loss of the graft. One of our associates has had one death following operation, probably from shock and anesthesia in case of a large incarcerated hernia. This patient was greatly overweight and a very poor risk. Another one of our associates has had two rather extensive infections. In one of these cases the graft was lost.

#### SUMMARY

After this clinical experience with the uses of cutis (derma) in repair surgery, I am convinced that cutis is the most useful auto-plastic repair material that we have; that it is superior in strength to fascia lata and of much easier availability; that success in its use can be expected in a large percentage of cases; and that it is of especial value in the surgical repair of many types of traumatic injury.

The following doctors have given permission to report their individual cases in which cutis grafts have been used: Dr. Bankhead Banks, twelve inguinal hernias; Dr. Hugh Bailey, one inguinal hernia; Dr. Randolph Anderson, five cases of wobbling knee; Dr. Howard Swart, one case of wobbling knee; Dr. A. A. Wilson, one dural repair; Dr. Victor Skaff, one dural repair, one suspension of the uterine cervix, two inguinal hernias; Dr. George Miyakawa, one fracture of the patella; Dr. Josef Haber, one abdominal incisional hernia, one suspension of the uterine cervix, one bilateral inguinal hernia with bilateral use of cutis and one inguinal hernia.

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## SHOULD NON-TRAUMATIC AND NON-INFLAMMATORY CHANGES IN THE SPINE BE COMPENSABLE?

JOHN D. ELLIS, M.D.  
CHICAGO, ILLINOIS

THE present tendency of Compensation Boards to award total permanent disability to older workmen who claim an aggravation of ancient pre-existing hypertrophic changes about the spine and spinal joints presents one of the commonest abuses of our legal system. Surgeons specializing in the treatment of injury and those who by necessity must explain what is traumatic and why to a lay jury or Compensation Board are at a tremendous disadvantage.

There are two definite reasons for the abuses arising out of this type of claim: The first is the result of a confusion of terminology inherent in the discussion of degenerative and inflammatory conditions. This is probably the result of the persistence of a concept in the minds of English speaking people based on the principles enunciated by John Hunter, who described various types of reaction to trauma as inflammatory, so that there is no strict differentiation in pathology texts between the invasion of tissues by infecting organisms and tissue changes resulting from mechanical trauma. When one says "bursitis" or "arthritis" such terms make no commitment as to whether infection or mechanical damage to the synovial lining, the blood supply or other soft tissues is being described. Unfortunately, we have no simple terminology which differentiates and will develop none until our concepts are more definitive.

The second arises out of the very nature of our present legal procedures. Nothing fits in so well with our system of cross examination as an attack by the examiner on a subject concerning which the terminology is confused. The whole difficulty devolves upon the inability of the surgeon of trauma clearly to explain what pathological conditions are traumatic or influenced by trauma and what is perhaps degenerative or hypertrophic, reconstructive or functional and wholly unaffected by trauma.

The purpose of this paper is to offer some brief, and we hope provocative, suggestions that may lead to the simplification both

of our concepts of the relation of trauma to certain non-inflammatory diseases of joints and our terminology in describing these conditions.

For the most part, this discussion will be confined to affections of the spine which exemplify the types of joint conditions in question.

In discussing the relation of trauma to these various entities this word "trauma" is employed in a special and definitive sense to mean a sudden mechanical external violence or a sudden single, unusual, unexpected occurrence and not to include the repeated and ubiquitous habitual stresses and strains or "microtraumatica" to which the spine of man is subjected in his daily work. In other words, we wish to distinguish the main disabilities of the back which may be of traumatic origin and those which are definitely not traumatic in origin and are unaffected by accident.

Recent development in roentgenological technic as a result of the efforts of Dittmar,<sup>1</sup> Ghormley,<sup>2</sup> Jordan,<sup>3</sup> Lange<sup>4</sup> and others make a diagnostic study of the normal and pathological aspects of the spine feasible; whereas, ten years ago the more intimate details of changes in the small articulations of the spine and their relation to changes in the bodies of the vertebrae were not possible.

It is most unfortunate for our purposes that the sub-committee on nomenclature of the British Committee on Chronic Rheumatic Diseases, appointed by the Royal College of Surgeons, in 1935 adopted a classification quite similar to the grouping of chronic affections of the joints advocated by the American Rheumatic Association. These two classifications with various modifications have now become generally accepted in the medical literature of the English speaking peoples. Such affections are divided into two great groups: (1) Rheumatoid arthritis, atrophic arthritis, infective arthritis, etc., (2) osteoarthritis, hypertrophic, degenerative arthritis, etc.

It is in the second division or group that we are vitally interested. It may seem presumptuous to attempt to offer a new classification in a field already confused by various terminology based on clinical, etiological, pathological or roentgenological data, or all of these. I believe that men interested in the estimation of the rôle played by trauma must of necessity adopt an entirely new nomenclature. They must definitely disregard any such prevalent terms as osteoarthritis, degenerative arthritis or hypertrophic arthritis in the description of diseases which are not inflammatory in nature.

One escape from our dilemma was suggested by Dr. A. W. George and Dr. R. D. Leonard, of Boston, who, in 1928, published a monograph "The Vertebrae,"<sup>5</sup> and stated, in substance, that they were discarding the terms hypertrophic and osteoarthritis entirely since they found that the various patterns of calcium salt deposition about the margins of joints of the vertebral arches as well as the hooks and spurs extending out from the attachments of long and short spinal ligaments are in nature entirely unlike arthritic deposits in their roentgenological appearance and anatomy.

Sometimes these calcifications have some resemblance to that which develops in the walls of arteries with the passage of time and the operation of various other non-traumatic influences. Certainly no one has contended that arteriosclerosis with subsequent calcification is traumatic.

George<sup>6</sup> finds that the pattern of these calcifications does not change nor their development increase or become accelerated after a trauma; therefore, he employs the term "hypertrophic changes" in his description. He says that in the abstracts of his monograph appearing in the literature of various countries of the world this change of nomenclature has been accepted. He also advises me in 1941 that Dr. Marius Smith-Petersen, of the Massachusetts General Hospital, Chief of the Orthopedic Service there, will not allow his students to employ the term "hypertrophic arthritis," when speaking of the vertebrae.

I am not sure that the term "degenerative" should be applied to calcifications about the spine, since while "degenerative" may be applied to some of the changes in the intimate structure of ligaments where they occur, the "buttressing" effect and ultimate substantial "bridging" tendency of these depositions may strengthen the spine locally or in general. Hence, viewing the whole spine as a structural unit they may be functional and not degenerative.

Therefore, I believe we should employ, and scrupulously adhere to, the nomenclature accepted in all continental medical literature. This, I believe, was first proposed by Frederick Mueller of Munich, at an International Congress on Chronic Rheumatic Affections in London in 1913<sup>7</sup> to emphasize the non-inflammatory nature of hypertrophic and osteoarthritis. He suggested the substitution of the term "arthrosis." He employed "spondylosis" in preference to spondylitis for all non-inflammatory or degenerative affections of the vertebral bodies themselves.

Since spondylosis, a chronic change of the edges of the bodies of the vertebrae, with development of ankylosing and projecting hooks, spurs and osteophytes, is the commonest condition seen in routine x-rays of the spinal column, and commonly occurs in spines entirely unaffected by any changes about the small joints which may be painful, Mueller described this as a separate entity. He also discussed changes about the small joints of the arches, ordinarily not painful and unaffected by trauma. These he terms arthrosis.

#### SPONDYLOYSIS

This is the commonest affection to which the vertebral column of man is subject. Calcification probably affects no other part of the skeleton so frequently as the spine. The changes do not constitute a disease *sui generis*. In some degree they may represent a physiological response to repeated mechanical stress, a kinetic or "formative" stimulation.

The age at which calcification appears in the costal cartilages, arteries, spine, etc., may be determined in part by hereditary tendencies. The term "spondylosis deformans" in a strict sense can be applied only when permanent changes in a series of vertebral bodies and ligaments are associated with lasting alteration of posture, usually with a kyphotic curve.

The occurrence of spondylosis increases with each decade past middle life so that Garvin<sup>8</sup> in 2,000 roentgenograms of the spine, made at the Mayo Clinic, chiefly for the study of the urinary tract, found that it was present in the lumbar region in 67 per cent of men and 40 per cent of women at fifty years of age, and that 74 per cent of these men and 61 per cent of the women had no complaints referable to the back. He, therefore, termed these changes "incidental" and said that the improbability that a single accident was responsible in any way for the affection was quite obvious.

In the examination of 625 lumbar spines, Willis<sup>9</sup> found that no lipping existed in any of these at the age of thirty-five. At the age of forty-five, however, 83 per cent of those of heavy body type and 10 per cent of those of slender type showed spondylosis. At fifty years all the heavy type and at fifty-five all of the average type and at sixty years all of the slender type presented these changes. This shows the ubiquitous occurrence of this affection past middle age.

Searches for a possibility of an infective element in the etiology of spondylosis has been extensive and unsuccessful. Cecil, Nicolls

and Stainsby,<sup>10</sup> in 1929, Nye and Waxelbaum,<sup>11</sup> in 1930, and Gray and Gowen,<sup>12</sup> in 1931, who have extensively studied the bacteria factor in chronic arthritis are unanimous in finding entirely negative results in both arthrosis and in spondylosis. Various immunological tests, including streptococcal agglutinations and antistreptolysin test, have been totally unproductive of any positive results. Buckley<sup>13</sup> and others in England have run long series of sedimentation rates on these cases without being able to find any relation between abnormally rapid sedimentation and the existence of spondylosis. I have run 200 sedimentations by the Cutler method without one positive result, except such as were easily explainable by very definite sources of infection entirely independent of the spondylosis.

Investigation of the occurrence and character of the osteophytic growth at the edges of the vertebrae has been made in an exhaustive study by Schmorl,<sup>14</sup> who made an autopsy examination on 10,000 spines; and in a large series of spines by Shore,<sup>15</sup> of Cambridge University. Their results are interesting.

#### ANATOMY OF OSTEOPHYZES

The osteophytic changes which commonly arise as spicules or as fringes are lipping of the vertebral bodies on their anterior and lateral aspects. In Shore's series no osteophyte was found on the posterior edge abutting the spinal canal or the intervertebral foramen. Beadle<sup>16</sup> makes the same observation after a review of Schmorl's series. Osteophytes usually bear longitudinal striations corresponding to ridges in the ends of the bodies of the vertebrae best seen when they are of moderate size. Osteophytic production may be extensive enough to span an intervertebral space. An incomplete bridge should not be mistaken for fracture of an osteophyte, although such a condition is not painful or of clinical importance. Almost never is osteophytic production limited to a single unit of the vertebral column. I am not referring to the regular callus depositions after a vertebral fracture, which have distinctive morphology ordinarily distinguishing them quite easily from actual osteophytic lipping. Since the work of Schmorl many writers have mentioned the collapse of an intervertebral disc as the important etiological element in the development of marginal lipping of the bodies; but if you will review any series of your own, as I have found in reviewing my routine x-rays of the back, even extensive osteophytic production

is ordinarily not associated with any diminution of the intervertebral spaces.

That spondylosis is not entirely dependent upon weight-bearing is exemplified in the study of the distribution of the osteophytes at different levels in Shore's series. In summary, his study shows that the liability of vertebrae to marginal changes increases as one goes from above downward with three well defined outcrops of spurs, one in the cervical region, another a thoracic outcrop, and finally a lumbar outcrop which is highest in the mid-lumbar region and falls to a minimum at the lumbosacral junction, where if weight-bearing were the definitive etiological factor the greatest pathological process would inevitably be found.

#### PATHOLOGY OF SPONDYLOYSIS

The entire vertebral column is enveloped in a continuous sheath of fibrous tissue, the perivertebral sheath described by Poirier and Charpy,<sup>17</sup> composed of a deep layer of short ligaments extending from one vertebral border to the next and attaching at the outer epiphyseal groove, which is the exact region where the osteophytic growth and lipping begins. In addition to this deeper sheath, there is a more superficial and powerfully developed layer specialized into the common anterior and common posterior ligaments. The powerful common anterior ligament is attached to each vertebral body at the outer edge of the epiphysis, superficial to the area where the osteophytes are produced. When these form they push the anterior common ligament forward, not invading it but are enveloped in the deep short and more delicate ligaments which attach each vertebral body to the one above or below. The importance of this distinction lies in the fact that the intervertebral discs and the deeper intervertebral ligament layers contain few if any pain or sensory nerve endings. Possibly the anterior ligament has some distribution of pain endings.

Since the osteophytes arise in the deeper and non-innervated ligaments and not in the common ligament, they are certainly not pain producing, as clinical evidence substantiates their common occurrence in non-painful backs.

In this description I am speaking of the innervation about the vertebral bodies in distinction from the innervation of the small joints of the arches of the vertebrae these are supplied like other

joints by synovial pain endings unquestionably affected by diseases producing pain.

#### FRACTURE OF THE SPINE AND Spondylosis

Through the research of Gagele,<sup>18</sup> Haumann<sup>19</sup> and Hellner<sup>20</sup> it has been definitely shown that generalized spondylosis does not result from a fracture of the spine. Subsequent observations of Max Lange,<sup>21</sup> of Munich, and Schmorl's investigations of a large series of spines corroborates this. I believe there has been a common tendency loosely to assume that after a compression fracture of the spine the changes produced about the affected vertebra corresponded to spondylosis. A careful roentgenological study of reconstructive changes about any compression fracture will confirm my own observations and those of the men cited above that callus formation is bizarre in character and conformation, and is not identical or even easily confused with the marginal osteophytes of spondylosis, which I have been describing.

#### DOES Spondylosis Proceed More Rapidly After Vertebral Fractures?

There is no evidence that spondylosis occurs after a fracture of one or several vertebral bodies or that it proceeds more rapidly after a vertebra has been crushed.

#### ARTHROSIS AND PAIN

Recurrent and persistent pain in the spine is not the result of chronic changes about the vertebral bodies but may result from structural changes in the small articulations. These articulations of the arches are the only true joints of the spine. Each articular process bears a facet which is covered with cartilage. The joints between these are provided with synovial cavities and a varying amount of synovia. The anterior parts of each of these synovial capsules forms a posterior margin of the intervertebral foramen to which the corresponding spinal nerves pass.

With the exception of the articulations of the cervical spine the development of the oblique view for the visualization of the small joints is a determining factor in our present ability to study pathological changes in these joints which prior to this time were very poorly understood.

The commonest affection of these joints is arthrotic in nature which is observed roentgenologically as: (1) Changes in consistency or density of the borders and bases of the articular facets, which finally progress due to degeneration and attrition of the joint cartilages allowing the unprotected bone on either joint surface to come in contact. Such a distorted joint may be painful. If such a joint is distorted enough to be painful, the pathological process can be very definitely demonstrated by *x*-rays.

The tendency to marginal lipping is not nearly so marked and occurs later in the course of these joint affections than in spondylosis. Strangely enough changes around the bodies even of advanced degree are not likely to be associated with any change around the spinal joints and conversely even advanced arthrosis in the latter position is commonly not associated by any marked degree of spondylosis, so that these two diseases are actually separate clinical entities not often found associated with each other.

Arthrosis is likely to occur at an earlier age than spondylosis. The most conspicuous calcifications about both the bodies and the joints of the spine are found in connection with static deformities, e.g., the dorsal kyphosis of later life, or that resulting from Scheuermann's disease. Scoliosis also have its quota of subsequent or secondary arthrosis. Only the advanced degrees of this disease present actual joint surface erosion and persistent pain due to this cause.

#### SACRALIZATION AND ARTHROSIS

In 748 skeletons Willis<sup>22</sup> found that 7 per cent presented a transverse process of the last lumbar vertebra which impinged upon, articulated with or was fused into the lateral mass of the sacrum. At first there was a considerable difference of opinion as to whether and how pain was produced by this sacralization. Bertolotti,<sup>23</sup> Leri<sup>24</sup> and Putti<sup>25</sup> thought that painful conditions occurring in this anomaly was caused by nerve pressure or venous stasis. Later roentgenological studies and directions silenced these contentions. Menard<sup>26</sup> operated upon thirty of these and found no compressions. We now know that like arthrosis of the spine a nearthrosis between a transverse process and the sacrum or ilium is or can be painful when: (1) Physical examination indicates objective evidence of local, painful disease;<sup>27</sup> (2) and when the *x*-ray shows a false joint which has a joint space obliterated, with little vestige of cartilage remaining and the joint margins thickened or distorted.

Quite similar criteria distinguish painless spondylolisthesis from a painful condition in this anomaly. It is well known that advanced cases of spondylolisthesis occur in which there is no pain and the finding is only incidentally picked up in connection with x-rays taken for other purposes than painful backs. Advanced arthrotic changes in the lumbosacral joints or in a nearthrosis formed in association with spondylolisthesis can unquestionably be painful.

I have seen many cases of fairly well developed spondylolisthesis in men who were working and who from time to time sprained their backs but recovered entirely. The question of whether spondylolisthesis demands a surgical intervention depends in a large part upon how much arthrosis has developed at the lumbosacral joints and whether it is of a painful or painless type.

#### CONCLUSION

1. The painless nature of chronic back conditions described roentgenologically by such terms as "hypertrophic changes," spondylosis and arthrosis can be determined with certainty by systematic physical and roentgenological examinations.
2. It seems in order to suggest that a committee from the American Association determine what terminology would best enable us to avoid the embarrassment of describing the non-disabling changes of advancing age in terms suggesting permanent or total disability.

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# CURRENT EXPERIENCES IN PLASTIC SURGERY AMONG NAVAL PERSONNEL\*

LIEUT. COMDR. PAUL W. GREELEY  
MEDICAL CORPS, UNITED STATES NAVAL RESERVE

**T**HE present military conflict has given rise to a rather wide group of traumatic lesions, which in time are brought to the attention of the plastic surgeon. Space will not permit a discussion of all of the interesting problems that are a constant challenge to the operator's skill and imagination. Since the injuries caused by burns are extensive and varied, I have chosen to limit this paper to a discussion of some of our experiences with this group of cases.

Burn injuries as they have been seen in our plastic service may be divided into four groups: (1) systemic damage; (2) repair of granulating cutaneous defects; (3) late correction of healed scar contractures and (4) unusual complications.

## SYSTEMIC DAMAGE

We have seen many casualties who had been extensively burned and who for various reasons did not arrive at the mainland until several weeks after their original injuries. Usually the story recounted was that the patient was too ill to warrant earlier transfer and when he could be moved, rapid transportation facilities over several thousand miles of enemy infested land and sea was often difficult. Consequently, when these men would be admitted, two or three months would have elapsed following the initial burn.

On admission, a typical patient was found to be very emaciated and septic. True enough, large amounts of plasma and blood transfusions had been given, but open infected granulating defects amounting in many cases to several square feet of surface area, permitted the very rapid escape through them, of large quantities of the patient's serum. The blood studies showed anemia and a low serum protein level. Owing to the pain associated with a lesion of this type large amounts of opiates had been given. This was of course a necessity, but the prolonged use of this type of drug lead

\*The opinions and views set forth in this article are those of the writer and are not to be considered as reflecting the policies of the Navy Department.

to a few minor cases of addiction. While the problem was readily corrected after skin grafting had been started, it did contribute to the patient's loss of weight through lack of appetite. A septic fever was a common occurrence until the patient had been properly prepared and skin grafting operations instituted.

With the foregoing picture it is quite obvious that we were dealing with a poorly nourished, anemic, septic, and emaciated group of patients. They were very sick individuals that needed much preoperative preparation before any surgery could be undertaken.

Varying amounts of serum and blood were given by transfusion. It was difficult to specify any adequate dosage, but it seemed quite evident that we often erred by giving inadequate quantities. Generally speaking, however, we attempted to give enough blood plasma to maintain a normal serum protein level. Blood was given in quantities sufficient to keep the hemoglobin reading up to 80 per cent and the erythrocyte count to 4,000,000 or more.

Since the majority of our patients had suffered serious and extensive extremity burns, adequate recipient veins were difficult to find. Consequently, we found it necessary frequently to use the jugular veins and to utilize the procedure of sternal infusions. This latter technic<sup>1</sup> is very simple and we believe from our rather extensive experience, that it should be utilized much more frequently.

The granulating defects themselves were prepared by a combination of treatments. The patient was given daily tub baths insofar as his physical condition would permit. This aided markedly in the loosening and floating off of crusts, pus, and other débris. The actual solution in which the patient soaked as a rule, did not seem to make a great deal of difference. Those who were bathed in plain warm water apparently progressed as well as those who were placed in physiologic saline or other solution. In other words, the benefit derived from tubing seemed to be due chiefly to the physical effects produced by the solution into which the patient was placed.

All of the granulating defects were badly contaminated with *Bacillus pyocyanus* infections as well as many other mixed organisms. The oral administration of sulfonamides gave no apparent benefit in our group. Their local application was of questionable value and in some instances gave one the impression that the local use produced excessive fibrous tissue reaction that manifested itself by undue contracture formation beneath the skin grafts. Several patients were given large doses of penicillin. This drug has

a very beneficial effect upon the mixed group of contaminating organisms, thereby making apparent a diminution of purulent discharge. It also aided the patient's general welfare by producing an increased appetite. However, we failed to note any effect whatsoever in controlling the *Bacillus pyocyaneus* infection in any case.

Following the tub bath, the granulating defect is covered first with sterile fine mesh gauze\* and then a moist sterile gauze roll applied under moderate pressure. Sufficient catheters or Carrel tubes are incorporated into the dressing so that the mass may be kept moist by frequent irrigations through the tubes. The moisture is maintained further by keeping the dressing enclosed in wax paper, which in turn is covered with a large abdominal pad and secured with an Ace bandage. We have employed various solutions with which to keep the dressing moist. In our hands the use of a weak acetic acid solution did not seem to control *pyocyaneus* infection any better than saturated boric acid solution. However, the boric acid mixture appears to give cleaner wounds than when physiologic saline is used. Apparently the mild acidity of the boric acid exerts some benefit over saline. A few days of this type of treatment usually will give a clean granulating defect that will receive a skin graft. Incidentally, we have no hesitancy in skin grafting granulating defects that are contaminated with *pyocyaneus* providing the granulations themselves have a healthy appearance. The grafts will grow to almost a complete "take," and once the defect is covered with growing skin, the *pyocyaneus* problem is simultaneously corrected. Thus, in answer to many queries as to how we control the *pyocyaneus*, the answer usually given is to "cover the defect promptly with a properly selected type of skin graft!"

In addition to the local preparation, one should also give the patient a high caloric, high protein, and high vitamin diet. Additional vitamins are given by mouth. If the patient is at all able, we like to take him out of doors in a wheel chair where he will obtain additional stimulus from the warm sunshine.

#### REPAIR OF GRANULATING DEFECTS

Much has been written and said about skin grafts and the technical procedures involved in procuring them. For a long time I have advocated using "a properly selected type" of skin graft. This phrase implies that a certain amount of thought, experience, and

\* From the Division of Plastic Surgery, U. S. Naval Hospital, Oakland, California.

consideration is being given to any problem necessitating a skin graft. In brief, we have long since concluded that the operator should attempt to utilize the simplest possible type of graft to fit the need of the particular problem at hand.

In covering extensive granulating defects such as we see following third degree burns, we have found that thin split-thickness grafts, cut in large segments, will give the most ideal results as measured in percentage of good "takes" and functional results. Furthermore, when donor sites are at a premium, as has been our experience many times, the donor area may be used repeatedly. The so-called "pinch" and "flagstone" grafts have not been used on our service except in a few isolated instances when adequate donor areas could not be found from which to take large sheets of skin. Moreover, it has been our experience that large grafts "take" better than small pieces. But most important, an area covered with pinch or flagstone grafts leaves a very poor covering, both cosmetically and functionally. Because of the large amount of scarring that develops between the grafted areas it is often necessary to remove these coverings at a late date and replace the defect with a large single graft.

The method of cutting the large split-thickness grafts may be left to the individual operator's skill and preference. We use both the Padgett dermatome and the Blair-Brown suction box and razor technic with about equal uniformity of results. The free hand method is simple and more rapid when good extremity donor sites are available. However, when one must take the graft from a poorly nourished scaphoid abdomen or from a moving chest whose skin is sunken between the individual ribs, the Padgett dermatome is far more efficient. Whichever method is chosen, we prefer to cut the graft relatively thin, i.e., about one-third total skin thickness. While this thin graft may not give optimum functional results around kinetic areas such as the hands and fingers, it has a good certainty of "take" and will serve to convert the open draining lesion into a closed wound. When necessary, this covering can be looked upon as temporary and may be replaced at a later date in the presence of a clean surgical field and when all other conditions are sufficiently ideal to insure a complete "take" of a more complicated skin grafting procedure.

It has been very gratifying to note the rapid improvement that these patients make when their open wounds are progressively covered with growing skin grafts. The loss of serum protein is

stopped, the anemias disappear, temperatures become normal, the patient gains weight, and in all respects rapidly becomes a human being again.

We have not used skin from other individuals. In light of our present knowledge, these isografts will grow only for a short period of time. Thus far we have had no occasion to resort to their use.

We have tried various original and modified applications of the coagulum contact<sup>2,3</sup> technic but in our hands, we have not had any greater success than with the well standardized procedures. Furthermore, we have lost surface area in attempting to follow the Sano plan because of the contraction of the graft by virtue of its own elasticity. Moreover, we have noted repeatedly that when split-thickness grafts are applied a natural coagulum develops rapidly between the raw surface of the graft and the underlying granulating bed. In fact, we have often observed with amazement, the speed with which this natural physiological reaction occurs.

#### HEALED CONTRACTURES

After the granulating surfaces have been well healed and adequate physiotherapy has been given, during which period the patients have been encouraged to be up and about, go out on liberty and, in general, live a normal existence, certain late corrections may be indicated. The thin graft around a joint may not give sufficient elasticity to permit full range of motion. In addition, some lesions come in to us that have been permitted to heal by secondary intention. Either instance not infrequently gives rise to a contracture of variable degree about the joint that will need secondary revision. These, however, can be corrected quite ideally as an elective procedure and in the presence of a clean surgical field. This condition in a now otherwise healthy patient has produced excellent "takes" of our grafts when fundamental technical principles have been observed. In correcting these late deformities, we still adhere to the principle of utilizing simple methods whenever applicable. In the correction of dorsal contractures of the hands,<sup>4</sup> contractures of the elbow, axilla, popliteal area, and the neck,<sup>5</sup> we have found that the use of thick split-thickness grafts gives excellent functional results when a good normal subcutaneous fat pad is present upon which to place the transplant. However, it is believed that in replacing surface defects on the flexor surface of the hand and fingers, the more complicated full-thickness skin graft will give better elasticity and a

better weight-bearing surface. This latter fact makes the additional effort involved of definite value when one considers the need of maximum function on the individual's palmar surface.

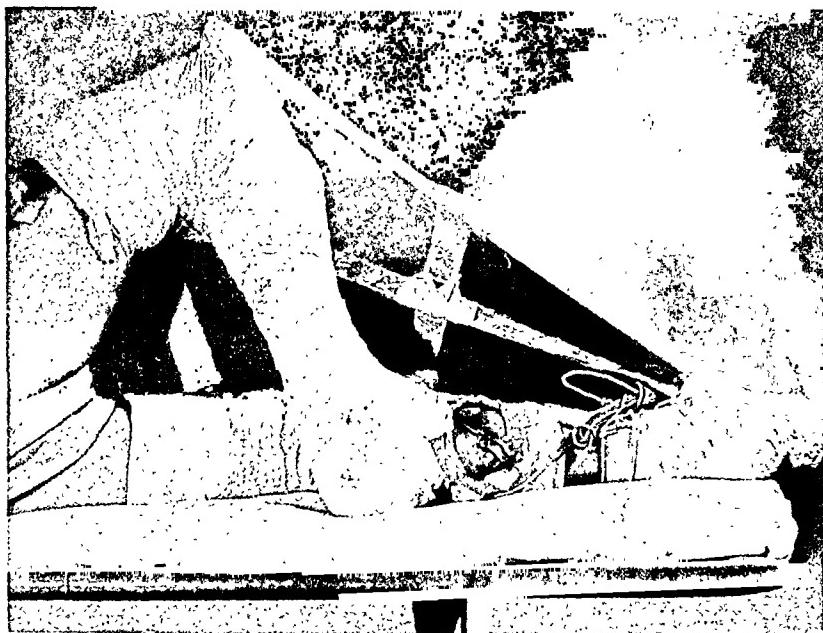


FIG. 1. This is not a cartoon of modern design. It exemplifies excellent engineering principles from the standpoint of good orthopedic immobilization. This patient necessitated a pedicle flap containing a fat pad to cover an extensive defect of his great toe. The simplest means to accomplish this end was to utilize a direct flap from the opposite calf. While this procedure gives an excellent end result, much could be said about the patient's comfort during the interval. It might also be added, that as a complication of the fixation, this patient developed an acute thrombophlebitis of the right lower extremity, and from this a small pulmonary embolus. This latter complication is not uncommon when awkward types of fixation inhibit normal muscular and circulatory activity.

The use of pedicle flaps is laborious, cumbersome, prolonged, and at times uncomfortable if the patient has to be fixed in an awkward position for a period of time. (Fig. 1.) However, when tendons, major nerves and blood vessels, and prominent bones such as the anterior surface of the tibia have been exposed, one should cover the defect with a skin graft to which is attached a good subcutaneous fat pad. This will entail the use of some variety of pedicle flaps. Again, if such a graft can be obtained nearby, a border flap frequently can be rotated over the defect and the donor area covered with a free graft. (Fig. 2.) This will eliminate construction of a distant tube pedicle or a flap from the opposite leg. Also, many

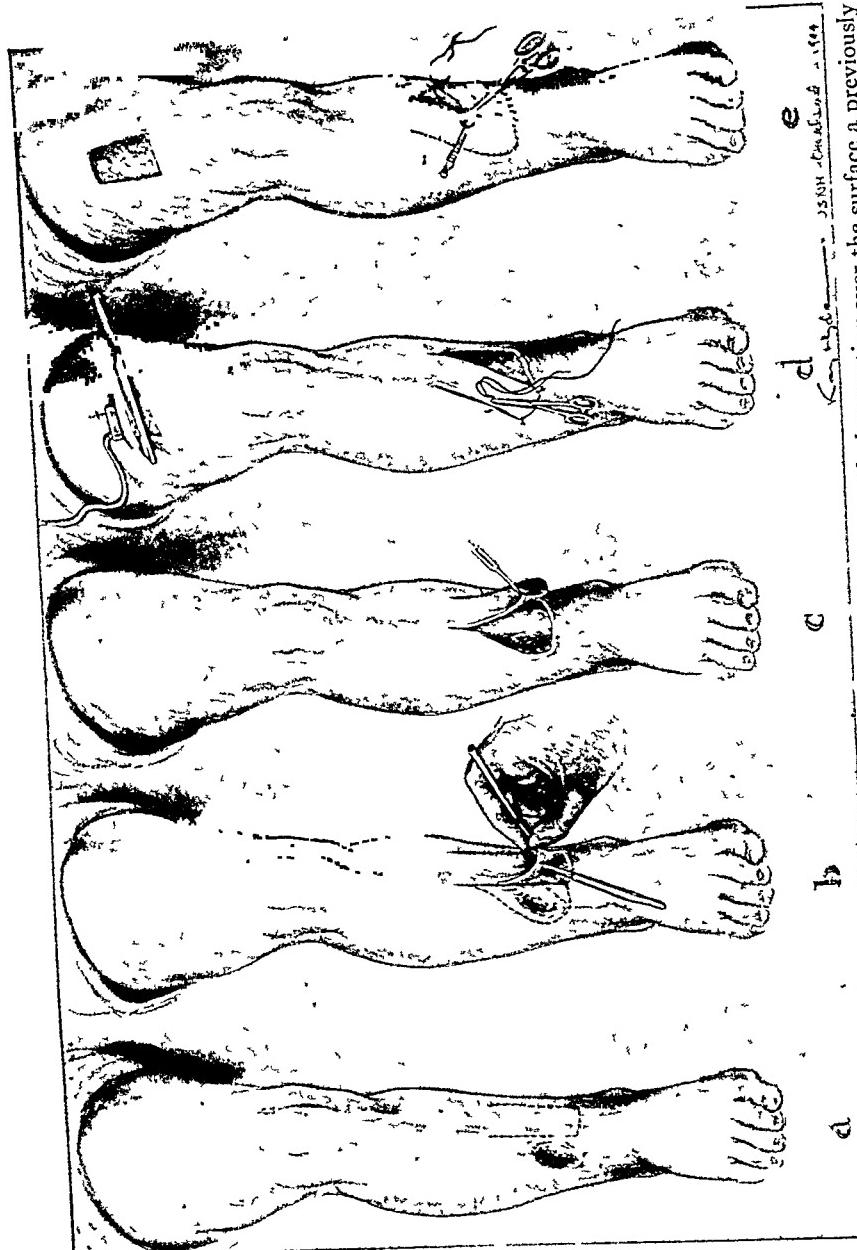


FIG. 2. Many defects over the leg can be covered simply and permanently by rotating over the surface a previously "delayed" border flap. The donor area can be covered with a split-thickness skin graft at the same operation.

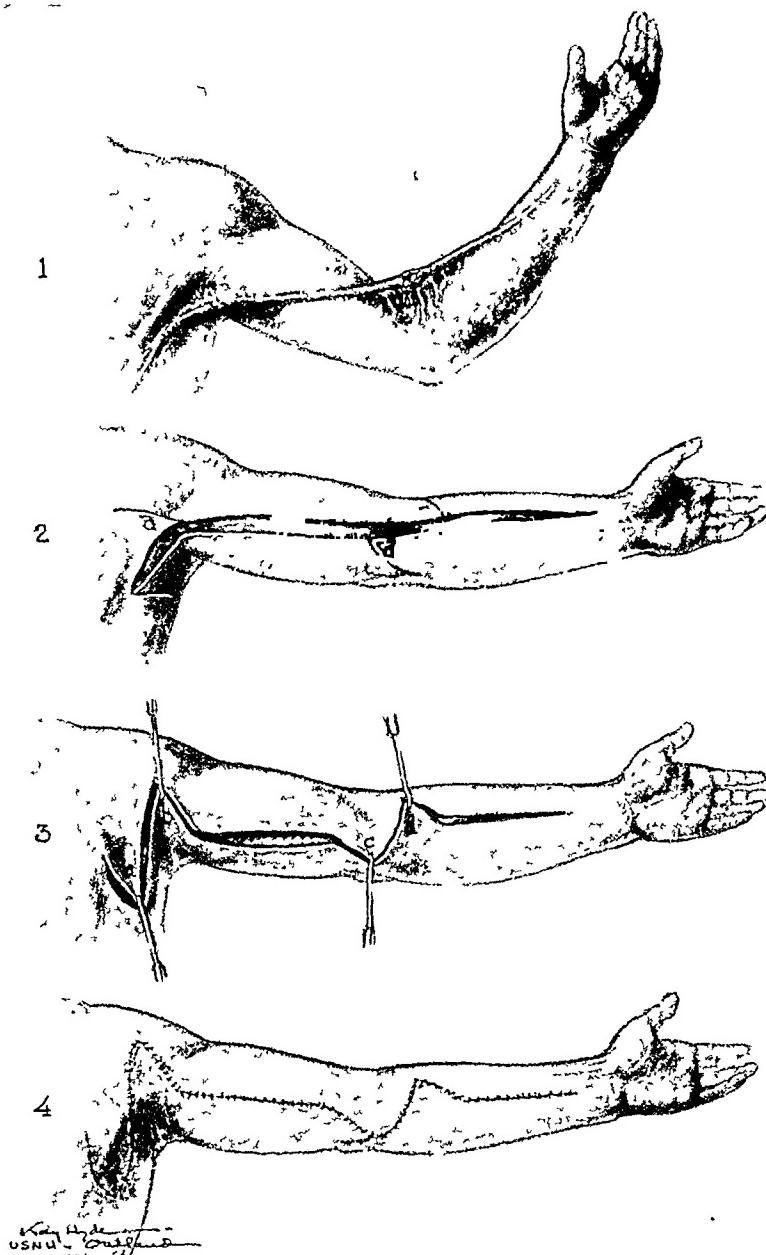


FIG. 3.—This patient was sent in with a long healed scar contracture that extended across both the cubital fossa and axilla. It followed an ill advised elective surgical incision. After complete excision of the scar, the straight line pull across the axilla and cubital fossa was eliminated by the construction of a double Z-plasty.

linear contractures may be corrected by a single or multiple Z-plasty (Fig. 3), thus again eliminating the necessity of bringing any new covering from a distant point.

Many deeper defects that follow burns will need future orthopedic, vascular, or peripheral nerve surgery. In anticipating this, a skin covering that will withstand reopening and other surgical trauma must be provided. Here again a type of pedicle flap must be utilized since its better blood supply will naturally allow for greater surgical liberties.

#### UNUSUAL COMPLICATIONS

While one might anticipate a wide range of sequelae associated with the management of burned patients who are severely ill, it has been gratifying to note that they have been relatively few. Several explanations may account for this observation. In the first place we have dealt chiefly with young individuals who were in good health at the time of injury. Excellent early management of the burns before being seen by us for late repair has done much to return a type of patient who responds rapidly when definitive surgery is undertaken. In addition, it should be mentioned that many of these extensively burned patients would have never reached our base hospital alive had it not been for the excellent clinical judgment used in the earlier care when plasma, blood transfusions and much hard work were contributed by those who carried out this portion of the treatment. Moreover, many extensively burned patients have arrived for plastic reconstruction that never would have survived before the days of plasma therapy. However, the three following unusual complications seem worthy of mention at this time:

The first of the interesting complications occurred in a twenty-two year old aviator who was admitted two and one-half months after having been shot down by an enemy pilot. He had suffered a complete loss of skin from the groin to ankle on each lower extremity. Before arrival here the granulations over both lower extremities were badly infected, the patient septic, anemic, and severely emaciated. He was prepared for skin grafting following the technic described above. One short skin grafting operation was performed at which time approximately 50 square inches of skin was placed over one knee and shin. Following this simple procedure, his temperature became normal and on inspection of his graft on the fourth postoperative day, we observed a 95 per cent "take."

The sutures were removed and the pressure reapplied. Two days later he developed another fever and within a few days thereafter, became deeply jaundiced. This we believed was due to a toxic hepatitis arising from the prolonged sepsis. Fortunately, the condition cleared with the aid of penicillin during the ensuing three to four weeks. Subsequently, the remaining defects have been covered without incident and the officer has been returned to duty.

Another patient, age forty-seven, developed an acute phlebitis following a simple skin grafting operation upon his ankle. Elevation of the part, hot fomentations, and massive doses of sulfathiazole gave rise to no improvement after forty-eight hours. The sulfathiazole was stopped and massive doses of penicillin substituted. The patient's temperature began to subside within four hours and was normal in eighteen hours. All tenderness along the course of the vein had disappeared completely and permanently two days after starting the penicillin therapy.

The third complication occurred in a young marine aviator. This officer had suffered third degree burns from his thigh to ankles of each leg when his plane had been shot down by the pilot of a "Zero." Upon admission to our hospital about two months after injury, each lower extremity was covered with badly infected granulations. The wounds and his general physical condition were prepared and the defects covered after several split-skin graft operations. During the course of the surgical procedures, it was noted that he had a foot drop on the right side. Neurosurgical consultation<sup>6</sup> was obtained and a definite lesion of the external popliteal nerve identified. It was believed that this lesion undoubtedly resulted from the heat of the original burn. In other words, while the nerve fibers were not interrupted by actual division, their conduction capacity was stopped as a result of the external physical insult. Time has proved this contention, since the function has gradually returned to nearly normal during the ensuing six months.

#### SUMMARY

1. Personal experiences in a rather wide group of burn casualties among naval personnel are discussed in detail.
2. Our observations in the management of (1) systemic damage, (2) repair of granulating cutaneous defects, and (3) the late correction of healed scar contractures are described.

3. Three cases of patients who developed unusual complications are presented.

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NOTE: Since presenting this paper we have been covering the granulations with a special fine rayon silk as suggested by Dr. Neal Owens.<sup>7</sup> This material has approximately 150 meshes per square inch, making it sufficiently porous to permit drainage but at the same time, rendering it extremely nonirritating and comfortable for the patient.

# LOCALIZED FIBROCYSTIC DISEASE OF THE FEMUR

A REPORT OF THREE PATIENTS TREATED  
BY CURETTAGE AND BONE GRAFT

LIEUT. COL. WILLIAM M. KRIGSTEN AND MAJOR GEORGE S. PHALEN  
MEDICAL CORPS, ARMY OF THE UNITED STATES

**L**OCALIZED fibrocystic disease of bone, or the so-called "bone cyst," is no longer considered a rare or unusual clinical entity. We believe it is sufficiently uncommon, however, to warrant this brief presentation of three interesting cases in which the patients were treated on the surgical service of an Army general hospital.

There are two distinct types of localized fibrocystic disease of bone: the solid lesions and the cystic lesions; but most authors believe that these simply represent different forms of the same non-generalized fibrous osteodystrophy. The solid lesions have been termed "polyostotic fibrous dysplasia."<sup>7</sup> Pathologically, these solid lesions are found to consist of a dense, grayish-white fibrous tissue containing a few bony trabeculae and completely replacing the normal medullary cavity of the bone in the region involved. One or many bones may be involved in the same individual, but in cases with multiple lesions, the involvement is predominantly unilateral. This well marked tendency to unilateral distribution lends credence to the theory that there is no hormonal basis for these lesions. Anatomically, these solid lesions may present themselves at any location in the affected bone.

In contradistinction to the solid lesions, the cystic lesions are usually fairly large fluid-filled cavities located in the shafts of the tubular bones. The cortex surrounding the lesions is thinned and expanded, and the cysts are lined by a thin connective tissue membrane. The fluid which fills the cavities is either clear and yellow or serosanguineous. These cysts are usually unicameral, that is, composed of a single chamber; but frequently there may be several partitions of fibrous tissue within the cystic lesion, dividing the cyst into several compartments. These cystic lesions are located nearly always in the shaft of tubular bones near the epiphyseal cartilage plate; and they very rarely extend across this epiphyseal plate.

In a growing bone, such a cystic lesion may appear to migrate toward the center of the shaft because normal bone may be laid down between the cyst and the epiphyseal plate. The proximal third of the humerus and femur are the most common locations for cystic lesions, although, of course, the lesions may occur in any bone.<sup>6</sup>

The pathogenesis of this disease is still an unsolved problem. A congenital abnormality of bone development, due to some primary germ cell injury or defect,<sup>1,7</sup> is probably the best solution as yet offered. It has been proved clinically that these localized bone cysts have little, if any, hormonal basis; certainly they are not due to any disturbance in the secretion of parathormone and are not to be confused with generalized osteitis fibrosa cystica (von Recklinghausen's disease).<sup>11</sup>

Some authors have suggested that these cystic lesions may be the healing forms of benign giant cell tumors.<sup>5</sup> The fibrous tissue lining the cyst, however, may contain a few foreign body giant cells but does not have the microscopic appearance characteristic of a giant cell tumor. Other investigators<sup>10,11</sup> have suggested that the cystic lesions represent a cystic degeneration of the solid fibrous lesions; but Jaffe and Lichtenstein<sup>6</sup> maintain that the fibrous tissue curetted from the wall of a cystic lesion is entirely unlike the tissue removed from a solid lesion. Hemorrhage into an area of softened bone has been offered as an explanation for the formation of cystic lesions,<sup>3</sup> but the cause of the softened bone remains a mystery. A few cases have been recorded in which no disease was noted at the site of a fracture until a month or two after the injury, at which time a cystic lesion became visible by x-ray. It is possible in such cases that an extensive hematoma within the medullary cavity of the bone may have organized and become cystic.<sup>4</sup>

Pommer<sup>8</sup> believes that mild trauma, not sufficient to produce fracture of a bone, may produce a focus of intramedullary hemorrhage. This focus becomes encapsulated and is kept distended by the transudation of fluid into it. Pressure from the cyst produces, in turn, a stagnation of blood and lymph, pressure erosion of bone and expansion of the overlying cortex.

Trauma and hemorrhage, however, are probably not the primary etiologic factors involved in the production of fibrocystic lesions of bone. As proof of this statement, in most cases there is no history of any previous injury to the affected bone; and although there are multiple bone hemorrhages in cases of hemophilia, cystic lesions do

not develop. It is probably better to assume that the fibrocystic lesions arise as the result of some local alteration in normal bone development. There is no evidence, either clinically or microscopically, to suggest that these lesions are truly neoplastic. Malignant degeneration has never been described in a fibrocystic lesion except in two cases mentioned by Allredge<sup>2</sup> in whom intensive roentgen ray therapy had been given. Although the condition may be thought to have a congenital origin, there is no clinical evidence to substantiate any hereditary transmission of the disease. An inflammatory origin of the fibrocystic lesions may be pretty well ruled out by the pathologic examination of tissue removed from the lesions, showing either no evidence of inflammation whatsoever, or occasionally a small focus of chronic inflammatory cells.

The occurrence of a fracture following a minor injury, such as a fracture through the proximal third of the humerus after throwing a ball, should make the clinician suspect the presence of a fibrocystic lesion. Such a pathologic fracture is often the first and only symptom of the disease. Many times, however, there is present a dull aching pain at the site of the lesion; and when the bones of the lower extremity are involved, a limp may be the first clinical sign. The roentgenographic appearance is quite characteristic: The area of bone involved has a rarified and often trabeculated appearance, with an expansion and thinning of the overlying cortex. One cannot tell, however, by x-ray examination alone whether the fibrocystic lesion is the solid or cystic type. Biopsy, of course, is the only absolute method of distinguishing a bone cyst from a neoplastic lesion of bone. From a roentgenologic standpoint, these fibrocystic lesions are indistinguishable from those seen in hyperparathyroidism except that the uninvolved portion of the bone is entirely normal and there is no evidence of generalized skeletal demineralization as is seen in von Recklinghausen's disease.

Interestingly enough, a non-union, or even a delayed union, of a pathologic fracture through a bone cyst has never been known to occur, despite the thin, expanded cortex and the replacement of the medullary bone by fibrous tissue or cystic fluid. In fact, there are many cases on record in which there was complete healing of the cystic lesion following the pathologic fracture; this does not occur, however, as frequently as one might hope it would. The fact that there is such remarkable improvement in the cystic lesion following the healing of the fracture justifies the delaying of any surgical

treatment of the lesion until it is seen whether or not the lesion will heal spontaneously. The healing of cystic lesions following pathologic fracture is believed to be due to the release of intracystic pressure, with its bone resorbing effect, and the stimulation of osteogenesis within the bone cyst.

Because these cystic lesions appear to be benefited by pathologic fracture, it seems logical to assume that good results should be expected from surgical treatment of the lesions. If the lesion is small, curettage alone may suffice; but when the lesions are large, as they usually are when pathologic fracture has either occurred or is imminent, curettage followed by the insertion of bone grafts is the treatment of choice. This is especially true in older individuals in whom the power of osteogenesis is lower than in younger individuals. Rogers<sup>9</sup> has employed massive tibial grafts in the treatment of two cases of cystic disease of the upper humeral metaphysis, the grafts acting both as an osteogenic agent and a means of internal fixation.

Cauterization of the cystic cavity is no longer considered necessary or advisable. In non-essential bones, such as a rib or the proximal end of the fibula, complete resection of the portion of bone containing the lesion is the preferred surgical treatment. X-ray treatment has not proved to be very successful in the treatment of bone cysts. Although pain, when present, is usually relieved by x-ray irradiation, epiphyseal arrest may occur following treatment, and malignancy may develop in cystic lesions treated by heavy irradiation. We concur with Allredge<sup>2</sup> that roentgen ray treatment of bone cysts should be employed only in the inoperable cases.

During the past year we have had occasion to treat three patients with localized fibrocystic disease of the femur. In two of the cases, the lesion was cystic in nature and involved the distal and proximal end of the bone, respectively. In the third case, the lesion was solid in nature and involved the mid-portion of the shaft. In all three cases, blood chemistry studies failed to show any alteration in the normal calcium, phosphorus and phosphatase levels; and roentgenograms of the other long bones, as well as the skull, failed to show any other cystic lesions.

#### CASE REPORTS

CASE I. A twenty-one-year-old private was admitted as a patient to the hospital on March 5, 1942. He stated that he had never experienced



FIG. 1. Case 1. Roentgenograms of right knee. A, anteroposterior view; B, lateral view, taken three and one-half months following pathologic fracture through an extensive cystic lesion involving the supracondylar region of the femur.

FIG. 2. Case 1. Roentgenograms of right knee. A, anteroposterior view taken six months following pathologic fracture, showing remineralization of the bones but persistence of the large cystic lesion in the supracondylar region; B, anteroposterior view taken five and one-half months following curettage and bone graft.

any pain in his right lower extremity until January 4, 1942. On this date he was participating in an authorized baseball game, when another player slid into him, causing his right leg to buckle beneath him. He immediately noticed severe pain above his right knee and was unable to stand. He was taken to the local station hospital where x-rays revealed a fracture through the supracondylar region of the right femur. He was treated by Russell traction for a few days, and on January 13, 1942, a spica cast was applied.

The cast was removed on April 4, 1942, and physical therapy instituted to mobilize the right knee. Roentgenograms showed the fracture to be well healed; there was rather pronounced generalized osteoporosis of all the bones about the right knee; and in the supracondylar region, just proximal to the closed epiphyseal plate, there was a cystic lesion occupying almost the entire width of the shaft, with expansion and narrowing of the cortex in the medial supracondylar region. (Fig. 1a and b.)

The soldier slowly regained motion and strength in the right knee. By July, 1942, roentgenograms revealed that the bones about the knee were remineralized, but the cystic area in the supracondylar region remained essentially unchanged. (Fig. 2a.)

Because it was believed that the soldier could be returned to duty only after the cystic lesion was healed, surgical exploration of the bone cyst was performed on July 22, 1942. At operation, a section of bone, measuring approximately one inch (2.5 cm.) in diameter, was removed from the very thin cortex of the anteromedial aspect of the femur, just above the adductor tubercle. A multilocular cystic cavity was exposed. This cavity measured approximately two and one-half inches in diameter (6.3 cm.), was filled with clear straw-colored fluid and was lined with a thin layer of fibrous tissue. The cystic cavity was thoroughly curetted and almost filled with chips of bone removed from the shaft of the right tibia. A plaster cast was applied, extending from the mid-thigh to the toes. This cast was removed on September 16, 1942, and physical therapy was again instituted.

The soldier was discharged to duty on February 9, 1943. At this time he was walking without a limp, had 120 degrees of flexion in his right knee, and complained of only slight aching in the right knee followed prolonged use of the right lower extremity. X-ray examination at this time showed the cystic lesion to be well healed. (Fig. 2b.)

This case is of interest because the diagnosis of fibrocystic disease was not made at the time of the injury, although a review of the original roentgenograms did show the presence of the bone cyst in the supracondylar region of the femur. The bone cyst became more evident, however, after the demineralization of the femur which followed the immobilization of the lower extremity in a plaster cast. A pathologic fracture was not suspected at the time of the injury

because there was a history of trauma of sufficient magnitude to cause a fracture of a normal bone.

CASE II. A twenty-one-year-old private was admitted to the hospital



FIG. 3. Case II. Roentgenograms of left hip. A, anteroposterior view taken on admission, showing large cystic lesion involving entire neck of femur; B, anteroposterior view taken four months following curettage and bone graft.

on November 27, 1943. He stated that he first noticed a dull aching pain in the region of his left hip on or about October 15, 1943. There was no history of any antecedent injury or illness, nor had he ever experienced a similar pain in any other bone or joint. He paid very little attention to the condition until about a month later, when the aching became so persistent that he reported on sick call for treatment. A roentgenogram of the left hip revealed a cystic lesion involving the entire neck of the femur, extending well up into the head and well down past the intertrochanteric line. (Fig. 3a.)

Because of the imminent danger of fracture through the neck of the left femur, the patient was placed at bed rest. On January 5, 1943, the neck of the left femur was exposed surgically through an anterior iliofemoral approach. The cortex of the femur in this region was of egg-shell thinness. Immediately upon puncturing through the cortex, a clear straw-colored fluid escaped; this fluid was under considerable pressure and pulsated with every heart beat. A window approximately one inch (2.5 cm.) in diameter was removed from the superior aspect of the femoral neck,

and through this window the contents of the cyst were thoroughly evacuated. This was a unicameral (single chamber) cyst, and the fibrous tissue lining was very thin. A portion of the left iliac crest, including the anterior superior spine, as well as the major portion of the lateral table of the wing of the ilium, were removed, cut into small pieces and packed into the cystic cavity. The cavity was almost completely filled with bone grafts.

A double hip spica cast was applied postoperatively. This was replaced by a single spica cast on February 17, 1944. A short spica cast, extending from the rib margins to the knee on the left, was applied on March 6, 1944, and physical therapy was instituted to mobilize the left knee and ankle. This cast was removed on April 6, 1944, and a walking ring caliper (ischial weight bearing) brace was applied to the left lower extremity. The patient is still wearing this brace. Roentgenograms show that the cystic lesion is becoming well obliterated by bone (Fig. 3b), but it was deemed advisable to prohibit weight bearing on the left lower extremity for at least five months following the operation because of the danger of fracture through the neck of the femur.

It is remarkable, in this case, that a pathologic fracture through the neck of the left femur had not already occurred prior to the patient's admission to the hospital. There was certainly very little bony support remaining in the femoral neck. It is also rather unusual to find the fluid within a bone cyst under as much pressure as was present in this case.

CASE III. An eighteen-year-old private was admitted to the hospital on April 23, 1943, for further treatment of a simple fracture through the middle third of the right femur. He stated that he had never had any pain in any bone or joint prior to his present illness. On March 23, 1943, the soldier caught his foot in a rut while running during calisthenic drill, and fell to the ground, twisting his right leg beneath him. He immediately experienced severe pain in the right thigh and was unable to rise from the ground. He was taken to the local station hospital where roentgenograms of the right femur showed a pathologic fracture through a large cystic lesion in the middle third of the bone; there was very little displacement of the fragments. He was treated by adhesive traction in a Thomas splint for two weeks, and then a hip spica cast was applied. On May 26, 1943, a short spica cast was applied, extending from the rib margins to the knee on the right, and physical therapy was instituted to mobilize the right knee. The cast was removed on June 24, 1943, because roentgenograms showed that the fracture was well healed. (Fig. 4a and b.) A walking ring caliper (ischial weight bearing) brace was applied to prevent the patient from bearing much weight on the right lower extremity because of the danger of bowing at the fracture site.

The patient was permitted to leave the hospital on a seven-hour pass on July 10, 1943. Although he was walking with crutches and was wearing the caliper brace, he sustained another fracture of the right femur when he



FIG. 4. Case III. Roentgenograms of right femur.  
A, anteroposterior view; B, lateral view, showing large cystic lesion with healed pathologic fracture two months after injury.

stumbled and fell down two or three steps at a private home. This second fracture was not at the site of the previous fracture but was through the proximal portion of the cystic lesion.

The patient was returned to the hospital by ambulance and was placed in bed with Russell traction on the right lower extremity. Because of a persistent respiratory infection it was not possible to operate upon the right femur until August 4, 1943. On this date, the proximal and middle thirds of the femoral shaft were exposed subperiosteally through a lateral approach. The cortex overlying the cystic lesion was found to be expanded and markedly thinned. A window, measuring approximately five inches (12.7 cm.) long and one inch (2.5 cm.) wide was removed from the lateral aspect of the cyst. The cyst was found to be filled with a yellowish, gritty fibrous tissue of rubbery consistency; there was no evidence of any fluid or any cystic areas within the fibrous tissue which filled the cyst. When all of this fibrous tissue was removed, there remained a cavity, measuring approximately six inches (15.2 cm.) in length and two and one-half inches

(6.3 cm.) in diameter, covered by a very thin layer of cortical bone. A large graft was removed from the left tibia and inserted into the cyst, extending well into the normal medullary cavity of the femur both above and below the cyst. The original fracture through the cyst was found to be well healed, but there was still motion present at the second fracture site. A portion of the outer table of the wing of the right ilium was also removed, cut up into small sections and inserted as bone grafts in the cystic cavity. With all this bone it was possible to fill only the anterior two-thirds of the cavity.

Microscopic examination of the tissue removed at the time of operation revealed a morphologic appearance in keeping with the fibrous repair of a bone cyst. The pathologist, Major G. D. Ayer, Jr., M.C., stated in his report: "The central portion is made up of loose connective tissue arranged in irregular fasciculi. As the periphery is approached, the connective tissue is denser and on the surface there are slender spicules of trabecular bone with cellular fibrous tissue in the interstices. From place to place there are collections of macrophages with foamy cytoplasm and occasional foreign body giant cells containing pigment. In at least one location the cortical bone is reduced to a very thin shell which is perforated in places and penetrated by the cellular connective tissue and bone spicules that form the outer portion of the lesion."

A double hip spica cast was applied following the operation. This was replaced by a single hip spica cast in six weeks. A short hip spica cast, extending from the rib margins to the knee on the right, was applied on November 4, 1943, and physical therapy was instituted to mobilize the right knee and ankle. The cast was removed on December 9, 1943, and a walking ring caliper (ischial weight bearing) brace was applied to the right lower extremity. The brace was removed on February 25, 1944.

Although there was definite evidence of bony repair within the cystic cavity, there was not complete obliteration of the cystic lesion by April 20, 1944. (Fig. 5a and b.) There was an excellent range of motion in the patient's right hip and knee, but the patient complained of pain in these joints following a moderate amount of walking; and he was unable to walk for long distances without the use of a cane for support. He was discharged from the Army on a certificate of medical disability, since it was believed that he would never be able to perform the duties of a soldier even in a limited service capacity.

This case demonstrates well the use of a large intramedullary tibial bone graft both to promote osteogenesis within the cyst, as well as to maintain the position of the bone fragments following a pathologic fracture through the cystic lesion. It is also obvious that the roentgenographic appearance of this solid fibrocystic lesion

differs very little, if any, from that of the purely cystic lesions present in Cases I and II. One might suspect that the lesion in Case III would be solid instead of cystic only because of the location of the lesion



FIG. 5. Case III. Roentgenograms of right femur.  
A, anteroposterior view; B, lateral view, taken  
eight months after curettage and bone graft.  
The massive intramedullary graft is still read-  
ily visible, and the cystic cavity is not yet  
completely obliterated.

in the shaft of the femur instead of in the metaphyses of the bone. The distinction between the solid lesion and the cystic lesion can be made only at the time of operation. Although the operation in Case III did not result in complete eradication of the cystic lesion, we believe that the operation has definitely increased the strength and stability of the femur, and further pathologic fractures through this site will no longer be imminent.

#### SUMMARY

We have presented three cases of fibrocystic disease of the femur. Two of these patients had a purely cystic lesion, while the third had a solid fibrous lesion. In each of the three cases, the lesion described was the only such bone lesion present, and there was no evidence of any endocrine or hormonal disturbance. Although the

gross and microscopic appearance of the solid lesion differs from that of the cystic lesion, it is probably true that both have as their pathogenic basis some localized congenital abnormality in bone development. The clinical picture in both types of fibrocystic disease is very similar, and the surgical treatment in both types is the same. Each of these three patients was treated by curetttement of the fibrocystic lesion followed by insertion of multiple bone grafts. This type of operation resulted in complete obliteration of the two purely cystic lesions and almost complete obliteration of the solid lesion.

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## REFRIGERATION IN TRAUMA

REPORT OF A NINE YEAR OLD PATIENT WITH LOWER  
EXTREMITY GANGRENE, FOLLOWING DISLOCATION  
OF DISTAL FEMORAL EPIPHYSIS

HARRY E. MOCK, M.D.  
CHICAGO, ILLINOIS

THE utilization of refrigeration anesthesia in elderly patients afflicted with gangrene of an extremity, the result of diabetic or arteriosclerotic peripheral vascular disease, has become a recognized surgical procedure in the last three years. While in the fall of 1941 and in the spring of 1942 papers were presented on this subject at Omaha, Nebraska, and at Cedar Rapids, Iowa, without encountering a single surgeon familiar with the method, yet in the spring of 1943, when a similar paper was delivered before the Minneapolis Surgical Society, the author found that eight amputations under refrigeration anesthesia had been performed at the University Hospital in Minneapolis. Again, before the Oklahoma City Clinical Society in October, 1943, he learned that several cases of this nature had been amputated under refrigeration anesthesia in the University Hospital at the Oklahoma Medical School. Without a single exception, all the surgeons who had used the method were extremely enthusiastic about it.

The experimental studies published since 1938, by F. M. Allen,<sup>1-9</sup> of New York, combined with similar studies by B. Brooks and Duncan,<sup>10,11,12</sup> Wilson and Roome,<sup>13</sup> A. Blalock,<sup>14</sup> A. Blalock and Mason,<sup>15</sup> A. Blalock and Duncan,<sup>16</sup> and N. E. Freeman,<sup>17</sup> is chiefly responsible for the clinical acceptance of the chilling of tissues as a therapeutic measure. In 1941 and 1942, Allen and Crossman,<sup>18</sup> and Crossman, Ruggiero, Hurley and Allen,<sup>19</sup> and Crossman, Hurley, Ruggiero and Warden,<sup>20</sup> and finally Allen<sup>21</sup> in 1943, presented articles conclusively proving the value of refrigeration anesthesia. Further clinical observations on refrigeration anesthesia, with or without a tourniquet, have been published by McElvenny,<sup>22,23</sup> Tynes, Nichol and Wiggin,<sup>24</sup> Mock and Mock, Jr.,<sup>25</sup> Mock, Jr.,<sup>26</sup> Rupp,<sup>27</sup> and finally Richards.<sup>28</sup>

The latter's article appearing in *The Annals of Surgery* in February, 1944, has been called to this author's attention in numer-

ous letters as a condemnation of the method. A careful perusal of this article, however, shows a wholehearted acceptance of refrigeration anesthesia for amputations but a strongly critical attitude, based upon the study of two cases, concerning the use of refrigeration *with a tourniquet* in traumatized extremities where it is used for the control of infection either preceding or after reparative or reconstructive surgery. It is to be regretted that this author did not separate the proved and exceedingly valuable refrigeration anesthesia and the yet unproved and very doubtful maneuver of applying a tourniquet to a refrigerated extremity with a view of later removing the tourniquet without amputation. However, many experimental and clinical studies have demonstrated the value of refrigeration of an extremity *without a tourniquet* as a means of controlling infections, eliminating pain and shock, preserving certain parts of an extremity until collateral circulation has had time to become established, and even furnishing anesthesia for certain minor operations. Already we have abundant clinical proof of the efficacy of refrigeration in these conditions. But none of the experienced workers in this field has advocated or contemplated the use of a tourniquet with refrigeration, certainly not for more than the recognized physiological limit of time for these purposes. Refrigeration without a tourniquet is an entirely different situation from that depicted and criticised by Richards.

The following case is worthy of a detailed report because of the inherent dangers in this type of injury and the value of refrigeration in meeting the many problems presented:

#### CASE REPORT

F. W., a male, aged nine years, on March 4, 1944, while playing in a church yard, tripped over a wire and fell forward to the ground. Immediately pain and a definite deformity appeared about the right knee. He was taken to a nearby hospital where an x-ray revealed a complete separation of the distal epiphysis of the femur. A Thomas leg splint with skin traction was applied. Forty-eight hours later, under anesthesia, a closed reduction was attempted unsuccessfully. Again, traction was applied. On the eighth day a second effort was made to reduce the dislocated epiphysis by a method described by Smith, namely, acute flexion of the leg on the thigh. The next morning the surgeon noticed that the foot was cold and cyanotic. The leg was immediately placed in extension and heat applied to the extremity.

On the morning of the tenth day the author was called in consultation. The lad was suffering excruciating pain in the foot and leg, partially controlled by small, repeated doses of morphine. The patient's temperature



FIG. 1. Complete dislocation of distal femoral epiphysis with shaft of femur displaced distal-ward behind the dislocated and rotated epiphysis.

was 103° F. rectally, pulse rate 120, respirations 30. Examination of the throat, lungs, heart, abdomen and remaining extremities showed nothing abnormal. His white blood count was 19,000.

Examination of the right lower extremity showed bluish discoloration of the foot and ankle, with a gradual change from bluish to a dusky red appearance up to within a few inches below the knee joint. No pulsation could be felt in the popliteal, posterior tibial or dorsalis pedis arteries. Hypoesthesia gradually merged into complete anesthesia from the knee

to the foot. There was some soft tissue swelling with definite bony deformity about the knee joint, especially in the popliteal space. Gangrene of the right lower leg was obvious, and it seemed probable that the gangrenous process would involve the entire leg.

Examination of the x-ray films showed the distal fragment pulled posteriorly and the shaft displaced behind it into the popliteal space. (Fig. 1.) The gastrocnemius muscle was attached chiefly to the posterior surface of the epiphysis and partly to the diaphysis. Thus, the pull of this muscle usually gives this characteristic displacement of the fragments when a complete dislocation of the epiphysis occurs. The displacement of the shaft of the femur behind the flexed epiphysis conceivably gives marked compression of the popliteal vessels and nerves.

As a consultant, the author was confronted with a case that had gone beyond the stage of mere congestion or beginning ischemia. Due to the long continued pressure on the popliteal vessels it was now a definite case of gangrene. Infection was imminent, if not present, in this extremity, as judged by the temperature and the excruciating pain. The entire lower leg had been wrapped in hot fomentations by the attending surgeon and kept very warm by an electric light bulb suspended in a cradle over the leg. Prior to his experiences with refrigeration, this is the therapy the author would have used. The same is true with the majority of surgeons. However, this heat was calling for a greater metabolic demand on the part of the tissues than could possibly be supplied by the retarded circulation. The moist heat sooner or later macerates the skin thus opening portals of entry for infection. On the other hand, chilling of this entire lower extremity would place the part in a state of hibernation. The metabolic demands would be reduced to a minimum. The blood in the vessels, as proved by clinical experience and experimental work, would remain fluid. Bacterial growth or invasion would likewise be retarded. Cellular breakdown with the formation of histotoxins, the absorption of which is the most probable cause of shock in such conditions, would be minimized. Finally, a certain degree of anesthesia would develop in the part with disappearance of pain.

All of these factors were explained to the family physician and the attending surgeon. The moist heat was then changed to refrigeration. A large rubber sheet was placed beneath the leg, from the middle of the thigh to below the foot. Eight ice bags were placed about the leg, from just above the knee to the foot, four on the posterior and four on the anterior surfaces of the leg. The rubber sheet was then wrapped about the ice bags and the extremity, making it practically an insulated, air-tight compartment. The author did this refrigeration maneuver himself and at the same time instructed the nurses concerning the vital importance of keeping the part constantly refrigerated. In order to secure their co-operation the

rationale of refrigeration was carefully explained to them. Certain failures in the past have been due to the lack of this understanding and co-operation.

The question of immediate operation of the dislocated epiphysis was raised. In one way it seemed logical to correct the deformity and relieve the pressure on the popliteal artery as soon as possible. On the other hand, the boy was in a very serious condition from shock and probable infection. Time was needed to overcome these conditions. Furthermore, it was questionable if any of the lower leg could be saved. If the amputation site eventually was to be above the knee, it seemed more logical to amputate through the epiphyseal line rather than subject the patient to two operations. Again, there was the possibility of a stiff knee, in which case an amputation above the knee was more desirable. Therefore, it was decided to give the boy forty-eight hours, during which period a blood transfusion and the refrigeration should improve his condition for amputation. Conditions present definitely indicated complete occlusion of the popliteal artery and further delay would not jeopardize the limb.

Thirty-six hours after refrigeration started, the patient was transferred to St. Luke's Hospital. When admitted, the bluish to bluish-red discoloration extended to the level of the knee. It seemed to all who viewed it that the entire extremity was gangrenous and should be immediately amputated. Refrigeration, however, was continued and the extremity was never exposed to room temperature for more than two or three minutes.

The day after admission the nurse greeted us by saying, "The whole extremity looks lighter in color, especially just below the knee." Examination showed this to be true. It is characteristic of the extremity refrigerated without a tourniquet to change from the dark bluish discoloration to a pinkish-white pallor. Eventually, the line of demarcation becomes quite definite. The viable portion above is a pinkish-white without any cyanotic areas, while the portion below the line has a pale bluish, cyanotic appearance. Refrigeration was continued day after day on the boy's leg for two weeks. During this time we witnessed a gradual return of the pinkish-white color to the upper seven inches of his lower leg, indicating the gradual establishment of collateral circulation.

This phenomenon has been witnessed in at least five of the author's cases. We are prone to refer to it as "preservation of tissues." This term has been criticized. It must be emphasized that none of the advocates of refrigeration believe for one minute that dead tissue is preserved and eventually revitalized. As Crossman succinctly stated in a letter to the author, "Dead meat in the refrigerator is always dead meat." However, gangrene threatened an entire extremity, and inevitably occurred too often under our old methods of management by heat and the lack of control of infection; but under refrigeration, preservation of part of the tissues otherwise condemned is frequently witnessed because of the waiting period. Time is given for the compensatory enlargement or dilatation of the

collateral vessels with establishment of collateral circulation. No instance of complete securement of collateral circulation has been witnessed by this author or reported by others where true gangrene exists. Gangrene and infection which are spreading rapidly up a leg are halted by refrigeration, and the collateral circulation marching downward preserves tissue which otherwise would become gangrenous.

Twenty-four hours after admission to St. Luke's Hospital this boy was absolutely free of pain. His temperature varied from 99 to 100° F. rectally. He had absolutely no complaint of chilliness in the remainder of his body, due to the refrigeration. The second day an open reduction was done on the dislocated epiphysis. An effort was made to maintain reduction and yet re-establish knee function if possible. Furthermore, it had to be immobilized without interfering with the refrigeration and without risking pressure sores from a splint or cast.

At operation the patient was given morphine sulfate, gr.  $\frac{1}{12}$ , and scopolamine, gr.  $\frac{1}{200}$ , and a very small amount of nitrous oxide. The anesthetist remarked that even though a tourniquet was not applied, the refrigeration for eighty-four hours had anesthetized the part almost completely. An incision was made along the medial border of the quadriceps muscle, just above the knee joint, down to the bone. When the soft tissues were retracted, the condyles of the femur and the intercondylar notch presented in the wound. The short epiphyseal fragment was pulled downward and backward by the gastrocnemius muscle at almost a right angle. The shaft of the femur was displaced posteriorly and extended slightly distalward to the epiphysis. A Murphy skid was placed between the proximal end of the epiphysis and the distal end of the shaft, and the two were gradually raised into alignment. Flexion of the leg relieved the pull of the gastrocnemius muscle and allowed complete alignment of epiphysis and diaphysis.

*Skeletal Pinning and External Fixation (Roger Anderson Apparatus).* When the leg was straightened, both fragments tended to dislocate backward. In order to immobilize the fragments and at the same time leave the knee free for movement, a skeletal pin was passed through the condyles of the epiphysis, extending through the skin on both sides. A second pin was passed through the skin on the lateral surface extending obliquely downward through both cortices of the epiphysis but not through the skin on the medial side. Two skeletal pins were next passed through the lateral surface of the skin and through both cortices of the femur, the proximal one extending through the greater and lesser trochanters, and the second one angling upward through the shaft and lesser trochanter. External fixation rods were then applied to these distal and proximal units, as well as from the pin which transfixed the condyles and protruded through the medial aspect of the thigh. (Fig. 2.) This Roger Anderson apparatus remained on the boy's leg for eight weeks. No infection developed about the

pin sites. After amputation it was possible to give exercises to maintain knee function. During the above operation refrigeration of the lower extremity to within three inches of the knee joint was continued.

*Refrigeration Anesthesia for the Amputation.* Two weeks following admission to St. Luke's Hospital, the line of demarcation was well established and the day for amputation had arrived. The Department of Anesthesia feared the psychological effect upon this young patient if the amputation was performed with him awake. However, the author felt perfectly justified in giving this boy the same benefit of a shockless operation witnessed in many an old diabetic patient who had undergone amputation by refrigeration anesthesia. The entire lower extremity, from six inches above the knee to the foot, had been refrigerated for two weeks, therefore, the skin was well anesthetized. The resident applied a double fold of soft rubber tube as a tourniquet above the knee without the least complaint of pain from the patient. The ice bags were then removed and the rubber trough was filled with two buckets of finely cracked ice that completely surrounded the entire extremity, from three inches above the tourniquet to the toes. This procedure was carried out at 8:00 A.M. At 10:00 A.M. the author visited the patient. From this point on it is necessary to become quite personal in order to depict the dramatic situation and the methods used to avoid psychological injury.

Frankie said, "Why did Dr. Eastman take away the ice bags and put the ice around my leg?"

I replied, "That's a darned foolish thing for him to do. Now I'll have to take you upstairs and clean the leg all up, take away the cracked ice and put the ice bags back. How about it, do you want to go?"

Frankie was anxious for any new move or excitement that would take him from the children's ward, and, accompanied by the head nurse from this ward, we went to the operating room. Without any ostentation he was lifted onto the operating table and after the operating team had scrubbed, the cracked ice was removed, falling into a dishpan with a great deal of noise and much joking with Frankie. An anesthetic rack had been set up that prevented him from seeing the preparation of the leg for operation. All this time the head nurse, the anesthetist who was ready to give gas, if necessary, and one of the interns, were talking and playing puzzles with Frankie. The tourniquet was still in place and the operation was started. The soft tissues were cut and flaps formed without the patient's knowledge. In fact, he and I were having a great time joking and laughing at each other's jokes. When I took the saw in hand I realized that he might hear the sawing of the bone. Therefore, I suggested a little drumming. The intern upturned a basin and each took a pair of 8-inch artery forceps to see who could beat the best tune on the improvised drum. Frankie beat the harder and we even sang to his tune. Meanwhile, the bone was sawed through. The operation was finished and the little patient was lifted back

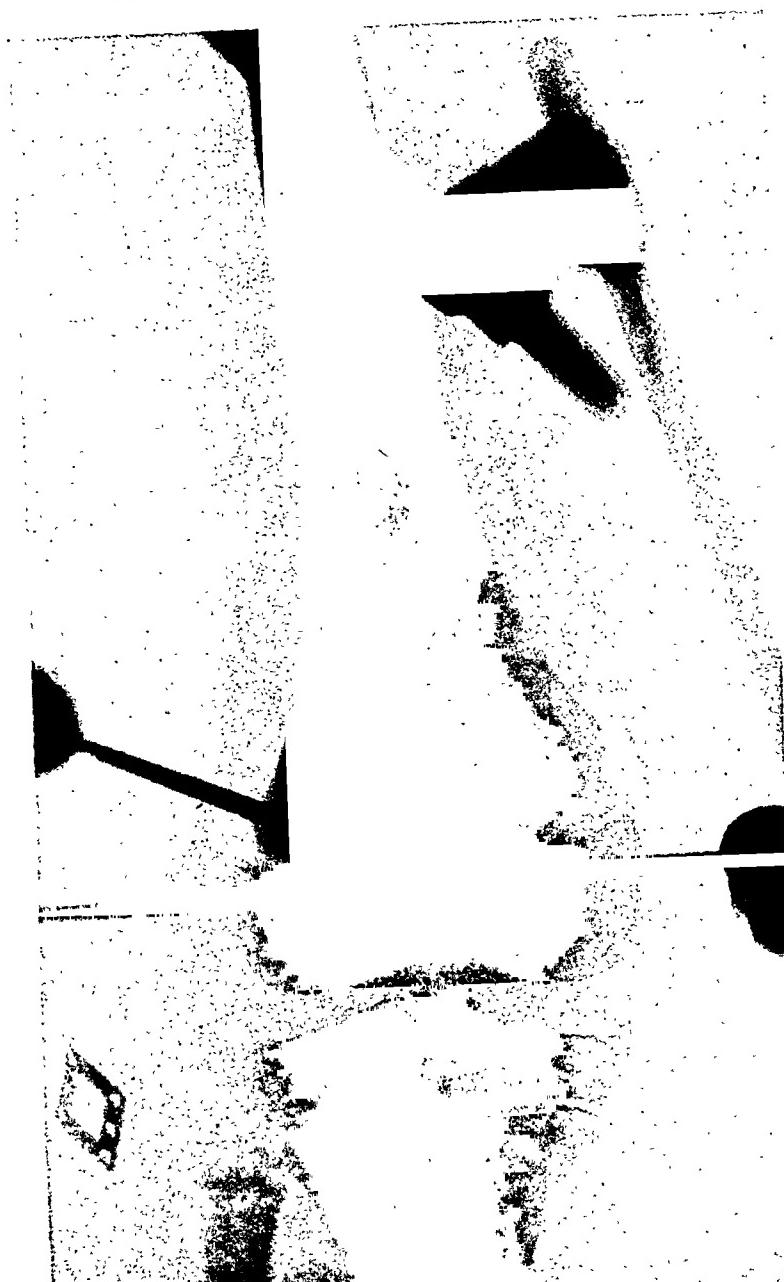


FIG. 2. X-ray film showing the reduction of the femoral epiphysis and its immobilization by means of skeletal pins and external fixation.

onto the cart with four ice bags applied around the stump. The operation was witnessed by at least eight visiting surgeons and interns and all were affected by the patient's complete absence of fear, any knowledge of the operation, and all remarked concerning the absence of shock. There was not even a change in the blood pressure which had been carefully recorded throughout the operation.

Thirty minutes later I went to the children's ward where the perturbed head nurse said, "Hurry in, Doctor, Frankie has just asked, 'Where is my foot?'" I went in and he repeated the question to me. I replied, "Frankie, you have two brothers over in the Pacific. If either of them had an old black foot like yours or the one you had, do you think they would want to keep it? And I'll bet that if either of them had to lose it, he wouldn't be as game about it as you were."

"Naw, they wouldn't keep it but they would be game all right," replied Frankie.

Two hours later the priest from the church where the boy was hurt visited him. He then came to me in the hospital and asked when I intended to amputate the leg. I told him it had already been done.

"Frankie is up there reading, and just the same as he was yesterday, and shows no sign of having been operated. You must be joking," he said.

The next day Frankie greeted me with, "When do I get my new leg?"

Never from then on did this patient show the least emotion over the loss of his leg. Psychologically speaking, there was never the least sign of a mental wound.

The skeletal pins were eventually removed. Perfect alignment between the diaphysis and epiphysis had been obtained. However, as Figure 3 indicates, the growth centers in the epiphysis have probably been destroyed. If this is true, any shortening that may develop in this extremity can be compensated for by lengthening the artificial leg. Exercises had been maintained throughout his convalescence. The stump of the lower extremity had been suspended in a hammock sling in order to preserve complete extension of the stump. As so often happens, there was a marked tendency to flexion deformity. By the end of four weeks the stump was completely healed. The stump could be completely extended and there was more than a 90 degree flexion at the knee joint. However, some eight weeks later a small sinus developed and a probe passed down this sinus led to the sequestra shown in the x-ray film in Figure 3.

Two weeks later the stump of this leg was again refrigerated over night, and the next morning a tourniquet was again applied above the knee and the stump surrounded with cracked ice. This was done with Frankie's consent and a complete understanding of its purpose. In giving his consent he modified it by saying that we could do the operation under refrigeration if he could watch it—"I'm going to be a doctor." Due to complications in the operation preceding Frankie's, the tourniquet was

in place three hours and fifteen minutes before we got to his operation. The stump and lower thigh to 3 inches above the tourniquet were completely surrounded by ice during this period. The sinus was dissected out

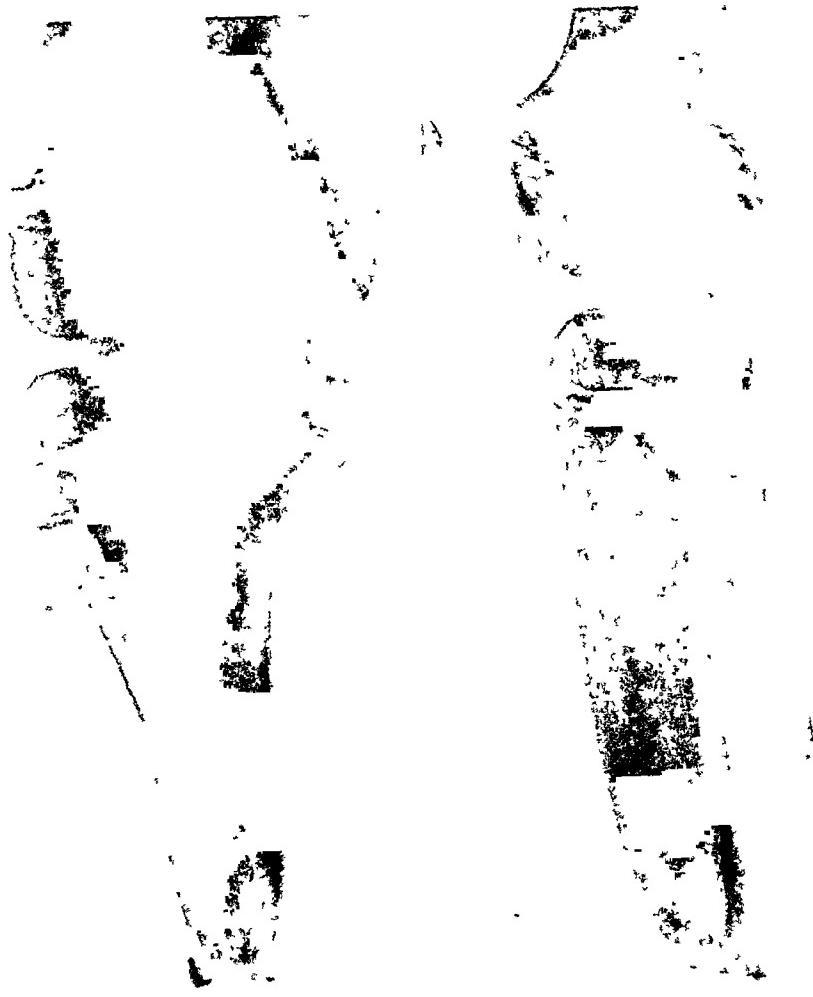


FIG. 3. A and B, the  $\text{r-ray}$  suggests complete fusion between the diaphysis and epiphysis of the femur with probable restriction of growth in this femur. Note the two small sequestra at the end of the tibial stump

and the sequestra removed with him watching the procedure. His only remark was, "It's just like working on a dead leg." Refrigeration anesthesia this time was used to prove the absence of previous psychological shock.

The lower thigh and stump have shown no deleterious effects from the three and a half hours of refrigeration and application of the tourniquet.

An artificial leg with a temporary socket is under construction. This boy will need very little rehabilitation as he has been thoroughly imbued with the spirit of rehabilitation.

#### CONCLUSIONS

1. A dislocated femoral epiphysis, like a dislocated knee, may be followed by gangrene of the lower extremity. As in one of the author's cases of dislocated knee, the original trauma may tear the intima loose within the popliteal artery, thus gradually damming the blood stream followed by a late thrombus and gangrene. In this case the popliteal artery showed no external evidence of injury. Again, the traumatizing force responsible for the dislocated epiphysis, or knee, may cause direct trauma to the popliteal vessels with their occlusion. Finally, the continued pressure of the dislocated parts on the popliteal vessels may be the etiological factor for the resulting gangrene. Complete dislocation of the distal femoral epiphysis must be reduced early and usually by open operation.

2. When gangrene follows such a disaster, it spreads rapidly to the level of the popliteal space. Heat treatment, by calling for more blood supply, may stimulate collateral circulation, but it also adds to the danger of infection. Refrigeration places the tissues of the extremity in a state of hibernation, reduces metabolic demands, holds infection in abeyance and gives time for the establishment of the collateral circulation that may preserve a part of the extremity. In this case we feel positive it preserved six to seven inches of the lower extremity.

3. Refrigeration without a tourniquet can be continued indefinitely *without* deleterious effects upon the tissues. Refrigeration in this case, at the third operation, allowed the tourniquet to be applied for three hours and a half about the thigh without the least sign of damage to any of the tissues at or below the tourniquet site. Future experience may prove this to be a valuable method in the control of a spreading infection from an injured extremity, not gangrenous, and with the extremity living after the tourniquet is removed.

4. The skeletal pinning and external fixation in this case allowed the preservation of knee function which is so essential if full benefit from the prosthesis is to be obtained in these lower leg amputations.

5. This nine-year-old patient proves that refrigeration anesthesia is applicable to the young as well as to the old. It has its place in traumatic as well as in diabetic gangrene. In either instance the

amputation can be performed under refrigeration anesthesia without a particle of shock, either physical or psychological.

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# SURGERY AT A HIGHER ALTITUDE

MAJOR MERLE J. BROWN

MEDICAL CORPS, ARMY OF THE UNITED STATES

CAMP Hale, of which the Station Hospital is a part, is located high in the Rocky Mountains at an altitude of approximately 10,000 feet. When the hospital was opened there arose questions as to the effect of this altitude on various phases of surgery. Speculations began concerning the use of anesthetic agents, alterations in wound healing, alterations in fracture healing, post-operative complications, sterilization methods and variations in laboratory findings. Although there are small hospitals in nearby towns and villages where surgery is done, none of them had surgery performed on a large organized scale as was to be the destiny of this hospital. Since there were no available guides to follow in answer to many of the questions, the establishment of the surgical service was somewhat of a pioneering project.

Some of the physical characteristics of the atmosphere at the elevation of this camp are shown by comparison with sea level standards. The barometric pressure is reduced from 760 mm. of mercury to about 522 mm. of mercury. The percentage of oxygen in the air is the same as at sea level; viz., 20.93, while the oxygen partial pressure in the air is reduced from 160 to about 109 mm. of mercury. The oxygen partial pressure of alveolar air is decreased to approximately 60 mm. of mercury. The dryness of the air results in rather marked dryness of the mucous membranes of the upper respiratory tracts until acclimatization takes place.

The choice of anesthetic agents was of great importance. Ether, alone or in combination with nitrous oxide and oxygen, was used early in the development of the surgical service. When it was administered by the open drop method, it was found that about twice the usual amount needed for an ordinary operation was required at this altitude. Volatility of the ether seemed increased in the dry atmosphere and frost quickly collected on the mask. When ether, alone or in combination, was used for surgical anesthesia, cyanosis developed more readily than has been observed by the author at lower levels. The use of inhalation anesthetic agents was made more difficult by the lack of experienced anesthetists. The

choice of other agents became necessary. The surgeons administered their own local and spinal anesthetics while the patients were watched and checked by nurses or surgical technicians during the operative procedures. The extent of use of the agents used over a period of eighteen months is shown in Table 1.

TABLE I

	Times Used	Minor Complications	Major Complications	Deaths
Local (novocaine)	1076	0	0	0
Spinal:				
a. Procaine HCl	681	62	1	0
b. Pontocaine in glucose	321	20	0	0
Sodium Pentothal I.V.	125	0	0	0
Topical	216	0	0	0
Nerve or field blocks	54	0	0	0
Ether	5	cyanosis	0	0
Nitrous oxide-oxygen	1	cyanosis	0	0
Gas-ether-oxygen	4	cyanosis	0	0

It will be noted that cyanosis developed fairly consistently with inhalation anesthesia. There were no complications observed in the use of local, field block or nerve block anesthesia. Of the 681 procaine HCl spinal anesthesias, sixty-two showed minor complications manifested by nausea, vomiting or both. There were thirteen patients with blood pressure drops sufficient to give a syndrome of symptoms resembling mild shock. One orthopedic patient apparently developed a marked decrease in blood pressure, rapid pulse, thirst and pallor sufficient to be classified as a severe reaction. The patients having pontocaine in glucose had twenty minor reactions such as nausea, vomiting, blood pressure decreases and pallor. There were eleven failures with procaine HCl and four failures with pontocaine in glucose. Supplementary agents were used, such as local novocaine, sodium pentothal intravenously, and least of all, inhalation agents. There were no anesthetic deaths.

Operative experience soon proved that wound healing was not altered by altitude changes. Out of 1,276 operations classified as major procedures and 1,684 as minor procedures, there have been only nineteen primary wound infections. Serum pockets or small hematomas occurred in twenty wounds. One compound fracture of the radius and ulna, treated surgically by débridement and open

reduction with a bone plate, developed gas gangrene. This patient's life was saved but a supracondylar amputation had to be done. The treatment of primary and secondary infected wounds resulted in wound healing as would be expected at usual altitudes. The use of sulfanilamide crystals for wound frosting after débridement and hemostasis allowed the primary closure of accidental wounds which could not otherwise have been closed.

Training on rugged terrain at this camp resulted in an ample number of fractures, treated and observed, to conclude that bone healing is not delayed. Delays which resulted in the slow return of some patients with fractures to duty are explained more by the amount of ligamentous and soft tissue injury by the same forces that produced the fractures. Especially in fractures resulting from skiing, there must be tremendous tension and bending forces exerted before the fracture occurs. This is evidenced by the great amount of soft tissue swelling accompanying these fractures. There have been a minimal number of delayed or non-union of fractures. At a mining camp not far from this camp site, it has been considered, without proof, that fluorides in the water supply alter bone healing. The water supply at this camp does not contain the fluorides.

Surgical complications that have occurred are no different than those observed in any hospital at lower altitudes. The complications that have occurred in 2,980 operations are shown in Table 11.

There is a total of 193 postoperative complications of which ninety-eight, or nearly half, are concerned with the respiratory system. The small number of cases with atelectasis and pneumonia is considered to be the result of a rigidly enforced program of post-operative care. The one pulmonary infarct occurred in a patient who had a ganglion removed from a wrist. This procedure was performed under local anesthesia and the patient was ambulatory throughout his convalescence. The infarct occurred on the eighth postoperative day. The one patient with pulmonary embolism occurred on the ninth postoperative day following an appendectomy. The onset was rapid and death ensued in less than two hours.

Although the infectious diseases were few in number, they caused considerable concern. One patient developed appendicitis and required operation during the full-blown stage of exanthema of measles while the others followed operations. One scarlet fever patient developed an acute gangrenous appendicitis in the early desquamative stage of his rash. This patient developed postoperative intestinal

obstruction which was relieved by the Miller-Abbott tube. Rheumatic fever complicated the convalescence of a patient with a gunshot wound of the foot. Even though the postoperative courses of these patients were long and difficult, recovery was accomplished.

TABLE II  
*Postoperative Complications*

Type of Complication	Name of Complication	Incidence	Total Number
I. Respiratory	Upper respiratory infection	82	98
	Atelectasis	6	
	Bronchopneumonia	4	
	Atypical pneumonia	3	
	Lobar pneumonia	1	
	Pulmonary infarct	1	
II. Infectious diseases	Pulmonary embolus	1	98
	Measles	4	
	Scarlet fever	1	
III. Wound complications	Rheumatic fever	1	67
	Primary wound infection	19	
	Serum pockets	16	
	Secondary wound infection	18	
	Hematomas	4	
	Primary postoperative hemorrhage	6	
	Secondary postoperative hemorrhage	2	
	Gas gangrene	1	
	Hemarthrosis	1	
IV. Miscellaneous	Tonsillitis	5	67
	Stomatitis	2	
	Serum sickness	2	
	Cystitis	1	
	Reaction to Na morrhuate	1	
	Abscessed tooth	1	
V. Gastrointestinal complications			12
	Paralytic ileus—postoperative	4	12
VI. Deaths	Intestinal obstruction	2	6
		4	
			4

Wound complications were kept at a minimum for such a volume of surgery. In all clean surgical cases careful attention was given to aseptic technic, sharp dissection, hemostasis and careful approximation of tissues in the suturing of wounds. In the surgical care of potentially infected or contaminated wounds débridement, cleansing,

use of sulfanilamide crystals, and careful suturing resulted in primary healing in the majority of instances. These factors, together with the use of the finest suture materials, resulted in good wound healing.

There have been four deaths on the service. One was due to pulmonary embolism as previously mentioned. Another patient was operated upon for a dynamite blast wound which produced an evisceration, severe injury to his eyes, and loss of fingers of both hands. Death was demonstrated at the postmortem examination to have resulted from a severe concussion with edema and petechia scattered through the brain tissue. The remaining two deaths resulted from severe chest traumas which were not operated upon.

The sterilization of material and instruments for aseptic surgery is accomplished by steam pressure sterilizers at eighteen to twenty pounds of pressure with temperatures of 240 to 250°F. Sterilizing time of forty-five to sixty minutes is routinely used. It is unsafe to use boiling for instrument sterilization since the temperature at the boiling point is about 186°F. at this altitude. All items required in sterile technics are routinely cultured twice per week for aseptic control.

It is sufficient to say that blood shows a slight elevation in the red blood cell count and hemoglobin. The differential blood counts show no variation beyond that which has been seen at lower altitudes. There are no evident changes in blood chemistry. Basal metabolism studies are most affected by the atmosphere at this altitude. The manufacturer of the basal metabolism machine attempted to overcome these changes by recalibrating the instrument but results have not been satisfactory.

The general surgical lesions requiring operations which are commonly seen in the men of military age are for the most part congenital defects. Such defects include hernias, hemorrhoids, varicose veins and varicoceles. Soldiers are inducted with the potential defects which develop under the stress and strain of rigorous training. It has been impossible to determine whether the added element of mountain climbing in the training program contributes to the development of hernias. There have been 235 hernia (inguinal) repairs among 189 men in about eighteen months. Of this number fifty-six were bilateral inguinal hernias, one accompanied a hydrocele, and fourteen were present with varicoceles. Over 50 per cent were direct types. An attempt to make a follow-up study was carried

out with the uncertainty of assignment, transfer and movement of troops. However, at this camp, many men who were operated upon remained at or returned to the camp to make the study of more value than could be ordinarily expected. Of the 189 patients 125 were doing full duty without evidence of symptoms or recurrence; fifty-five were transferred to other field units and nine were disposed of by certificate of disability discharge because of psychoneurosis. Although about ten men complained of a tightness or pulling sensation in the region of the scar, there were no known recurrences in the entire group.

In all these hernia repairs only five primary wound infections occurred. One occurred in a repair of recurrent hernia originally operated upon before induction. Two were unexplained. There have been no extrusions of non-absorbable sutures except in one case. Secondary incisions were required in two cases to remove deeply buried sutures causing a chronic sinus. Healing resulted quickly after the removal of the buried sutures.

The medical service of this hospital diagnosed and treated 252 atypical pneumonias, sixty-nine bronchopneumonias and fifty-three lobar pneumonias in about eighteen months. Among these were ten pleural effusions and two empyemas. All effusions were treated by the surgical service. The simple effusions required from one to six thoracenteses for recovery. One of the empyemas complicated a streptococcal lobar pneumonia. Cultures of the fluid showed a virulent hemolytic streptococcus while x-ray studies demonstrated multiple pockets of fluid. The repeated aspiration of pus from all pockets, local instillation of penicillin, and general administration of penicillin resulted in a cure without further surgery. It was noted that cultures of pleural pus after the first intrapleural dose of 25,000 units of penicillin became negative. The second empyema complicated a pneumococcal lobar pneumonia. There was a massive effusion of pleural pus with mediastinal shift and severe respiratory embarrassment. At the height of this soldier's illness, unconsciousness developed and an heroic attempt at relief was made by doing a thoracentesis without anesthesia of any kind. Thirteen hundred cc. of thin pus were aspirated. It was expected that this patient would die but within four hours consciousness was regained and recovery began. Repeated aspirations and penicillin therapy, local and general, has resulted in recovery without further surgery. Each of these two empyemas due to different organisms have required one

million five hundred thousand units of penicillin. The free use of oxygen was required as a supportive measure in all these patients because of the mechanical reduction of vital capacity by the effusion and the decreased oxygen partial pressure of alveolar air at this altitude. The author believes that if all empyemas can be halted in their development and cures be obtained by this type of therapy, the mortality rate of empyema by other methods of treatment will be reduced to a minimum.

#### CONCLUSIONS

1. Surgery may be performed at higher altitudes with equal results of surgery at lower altitudes.
2. Wound healing and fracture healing are not disturbed by any oxygen variations at higher altitudes.
3. Two cases of empyema of severe types caused by pneumococcus and streptococcus hemolyticus have been cured by the relatively simple procedure of thoracentesis and penicillin therapy.
4. Follow-up study, as could be done in the armed forces, of 235 hernia repairs has shown no recurrences and only five wound infections

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## Editorial

### PIGEONHOLE IT FOR AWHILE

THIS is written right after New Year's Day, 1945. You will read it sometime in March or April. Perhaps much we have to say will seem distorted, unnecessary, old, or unmentionable by then.

Right at this moment the world is in an awful mess and we seem to be in the center of it. Not long ago the Germans on the Western front made a sudden drive and for awhile gave our boys a terrific pushing around. At this writing the news seems brighter. We have snub-nosed the tip of the salient and are denting the north and south lines. As we go to press the bulge is gone and almost forgotten. But we're holding our breath. Unconsciously we are in a subdued panic of apprehension. Out in the East the reports are rosy. We seem to be doing all right, but those in the know assure us we have a long, long way to go before we are in sight of victory.

Things must be serious. Horse racing in this country is OUT for the duration. "They" say it was a *mistake* that it was not shut down long ago. It is proposed putting the + F's on essential war work. About time! "They" say it was a *mistake* to let this class do no essential labor. It seems farcical for a big husk of a man playing professional football not in uniform because he has a hole in an ear drum, or another fleet-footed lad playing short-stop on a National league baseball team

because he has an arthritic ankle joint, but neither can tote a gun or work at a lathe. This is not the individual's fault; "they" ordered it done that way. Of course everyone can extend this list ad nauseum. Not long ago "they" stopped training air pilots and diverted them to other channels. Now, we hear, it was a *mistake* and "they'll" train pilots again. Suddenly as of midnight of the first day of the new year, food coupons became so much waste paper. The howl of the housewives will never down—or, at least not for many, many months. "They" said "they made a *mistake*." Billions of coupons had accumulated and the food was just not there. "Excuse it, please."

Recently orders have gone out to reclassify all lads doing farm work, reshuffle all 4 F's and see that those up to twenty-nine or so get into essential war work; and God help those who left a war job for a civilian job, having in mind post-war security. It was all a *mistake* "they" cry.

We look every noontime at a large group of medical students dressed in army and navy uniforms. They are studying medicine and Uncle Sam's paying their tuition, their expenses connected with this study, and also paying them around \$135.00 a month up, depending upon circumstances. We had to have medicos in the armed

forces, hence lower premedical standards. A boy was given two years of college work crammed into eighteen months; then he entered a medical school, and crammed four years' work into three years, and on top of this a nine months' internship. (God help us all!) In this way the government would get about five or six thousand extra physicians every four years. Last spring "they" began to curtail. The number of lads to be in uniform in the future would be noticeable by their lack of personnel. But we sit in dread. Any minute we fear "they" will say it was all a *mistake* and that we MUST have more physicians and so "they" will send us 10,000 boys just eighteen years old who have about completed a high school education—and "hurry it up." An instructor in a Medical School tells of a student who went to the washroom and missed the entire sophomore year.

"They" closed up factories. Now "they" are frantically building factories for goods to be delivered a year from now. "They" acknowledge "they" made a *mistake*.

Meanwhile prepaid insurance plans for medical and surgical care are breaking out like a measles rash throughout the country. "Oh, yes, no sense trying to do anything about it," we hear on every hand; "there's going to be many changes—we're in for Socialized Medicine, and we're going to get it whether we like it or not." So

much has been written and said on the subject the average person is in a mental haze. We know the Wagner bill is around the corner, like the wolf ready to spring. We admit, there is room for improvement. We are in a process of evolution. But we hope there will be a pause, that "they" will not pass legislation while 60,000 physicians are in uniform, the majority of them out of the country. It would be a calamity for hasty action now and later on to be informed that "they" made a *mistake*; and it is evident that the best minds at this time make many honest mistakes! There must be more important and pressing problems than this medical issue. It must be more important to get down to business and win the war and then win the peace; and, when this is done, it will be time sanely and soberly to consider the pros and cons of the subject.

So, as you read this we hope the news on all sides is tinted with a rosy hue, that our hearts are a bit lighter, that we listen to radio or read headlines without dreading the news will be bad; and we hope peace is truly in sight, just around the corner. Until and after that time we trust and pray "they" will leave the structure of medicine alone for a little while and not make other needless and unnecessary *mistakes*.

T. S. W.



# Original Articles

## TWENTY-FIVE YEARS' EXPERIENCE WITH PLASTIC RECONSTRUCTION OF THE BREAST AND TRANSPLANTATION OF THE NIPPLE

MAX THOREK, M.D.

Professor of Surgery, Cook County Graduate School of Medicine

CHICAGO, ILLINOIS

THE method of simple plastic reconstruction operation on the breast with free transplantation of the nipple, which I reported at a medical meeting in Chicago in 1921<sup>1</sup> and recorded in 1922,<sup>2</sup> is, with surgical experience and modern methods of anesthesia, advantageously carried out, bilaterally whenever necessary, at one operation. The results are, as a rule, uniformly satisfactory.<sup>3,4,5,6</sup>

The procedure is not only simple and less tedious for patient and surgeon than any of the long list of surgical methods familiar to us<sup>7</sup> but is also productive of best esthetic results. The simpler procedure, followed with scrupulous care as to exact apposition of surfaces, meticulous hemostasis, avoidance of unnecessary trauma to the tissues, and proper selection of suture material,<sup>8,9</sup> is free from the complications attendant upon the more elaborate and time consuming, multiple stage procedures. In such procedures, the dangers of infection and necrosis and the incidence and degree of scarring and keloid formation are greater than in the simple operation. (Figs. 1 and 2.)

*Operative Procedure and Technic.* It is important for the patient to be properly anesthetized to obtain successful results in my operation of plastic reconstruction of the breast and free transplantation of the nipple. I have, in recent years, been using intrasternal anesthesia in a large number of my cases with excellent results. Because of the advances in anesthesia and the

improved operative technic, I have abandoned operating on each breast at different periods. Both breasts may now be operated upon effectively at the same time. The time of operation should not exceed from an hour and three quarters to about two hours for both breasts.

In my previous technic, I used a solution of brilliant green for tracing the proposed lines of incision. This has been discarded. At no time should the outlines for the proposed line of incision be drawn when the patient is lying down. The patient should be in a semi-sitting position on the operating table. Every patient must be studied thoroughly prior to operation. Previously, I outlined the position of the nipples on the morning of the operation, but I have abandoned this because I found it best to outline the position of the nipples after the breasts have been reshaped and the skin flaps sutured.

The nipple and as much of the areola as is deemed advisable are carefully dissected free. After resection of the breast substance to the desired extent the raw surfaces are closely approximated to eliminate the possibility of leaving any pocket for hematoma formation which may become potential foci for tissue necrosis. The sutures should not be tied too tightly causing the tissues to appear exsanguinated and blanched. Cotton technic, with properly selected needles, is used throughout the operation for hemostasis and skin suturing.<sup>8,9</sup> As a rule no drains are used.

*Free Transplantation of the Nipple.* A circular area in the desired location on the reconstructed breast is now circumscribed

the nipples will become more or less discolored, but that such discoloration is temporary, without danger to the "taking"



FIG. 1. Undesirable results of multiple stage operations for pendulous breasts. Such cases are to be considered as failures because of unesthetic appearance of the breasts, conspicuous scarring and asymmetry.

FIG. 2. Same patient as in Figure 1; lateral view.

by a sharp pointed scalpel for the reception of the freely dissected nipple and areola. The object is to secure union between the raw surfaces of the nipple transplant with the exposed vascular bed on the remodelled breast surface prepared for its reception. Too deep excision is to be avoided as the implantation of nipple and areola on a purely adipose bed, notably poor in blood supply, may not yield the usual good results. The area of the excised nipple and areola should be slightly larger than that of the receiving bed, since upon removal, the nipple immediately contracts and difficulty in approximating the edges may lead to poor results. Using a fine cutting needle and fine cotton sutures, the surgeon fixes the nipple and areola in proper position with as many sutures as are necessary to obtain proper coaptation without tension. One may use fine chromicized catgut sutures with needles of proper caliber, if one prefers, for suturing the nipples in place.

It is important to explain to the patient that immediately following the operation

of the nipple and that the dark color will gradually but surely disappear. There will be no sloughing of the nipples if the proper technic is used. Soon the most superficial stratum of the skin is cast off. Under the discolored surface the transplanted nipple is healing and will be of pinkish hue as soon as the discolored layer is eliminated. Pigmentation will gradually take place. (Figs. 3, 4 and 5.)

As recently as September, 1944, Dr. Jacques W. Maliniac contributed an article to the *American Journal of Surgery* in which he states, "it is impossible to transplant the nipple free by now available technics." Many hundreds of successful cases of transplantation of the nipples afford ample proof refuting such a statement. Dr. Maliniac further states that microphotographic illustrations of such grafts point to the presence of skin elements only. This is quite correct. The nipple is nothing more than a highly organized skin structure, and the proof here offered again unreservedly contradicts Dr. Maliniac's statement. He asks for

"microscopic evidence of muscular fibers and ducts obtained from sections of transplanted tissue." Since erection of

proof of successful taking of transplanted nipples, and the histologic presence of muscular, ductal, nervous, glandular and

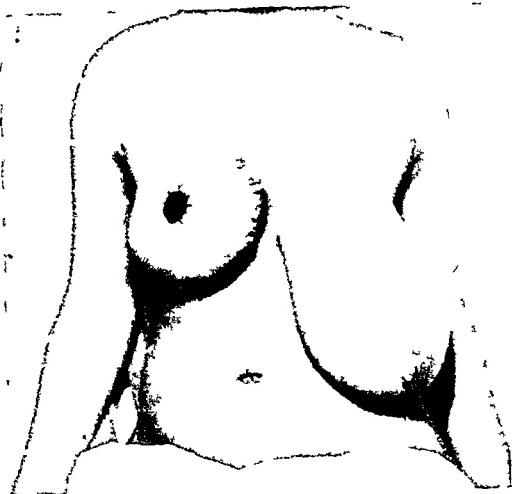


FIG. 3. Colored girl, fifteen years of age, bilateral virginal hypertrophy of the breasts First stage of author's operation completed. (Author's Service, Cook County Hospital, Chicago, Illinois)

the nipple depends upon the presence of muscular elements, and since this has been proved unmistakably by myself and others by clinical manifestations, the presence of muscular fibers must be admitted. William Milton Adams<sup>10</sup> states: "The purpose of this article is to give additional proof that free transplantation of the nipples and areolae can be performed." Adams confirms my observations: "There was a definite erection of the nipples on manipulation, which could only result from the contraction of the smooth muscle grafted with the nipple."

However, since Maliniac insists on proof of ducts in the microphotographic image, this gives rise to the question: Of what use are ducts in a nipple that is not intended for nursing? Markedly hypertrophic, pendulous breasts have little, if any, lactophorous function. Patients thus afflicted are primarily interested in obtaining relief, from discomfort (subjective and objective) and a satisfactory esthetic result, and not in the nursing of offspring. Nevertheless, we have accepted this challenge and offer below additional indisputable histologic

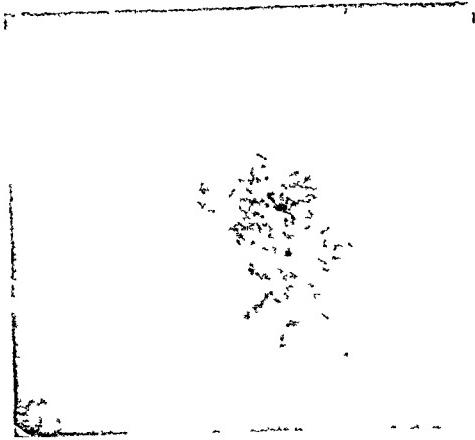


FIG. 4. Two months after transplantation of the nipple in colored girl. (Fig. 3) Note partial pigmentation of the nipple.

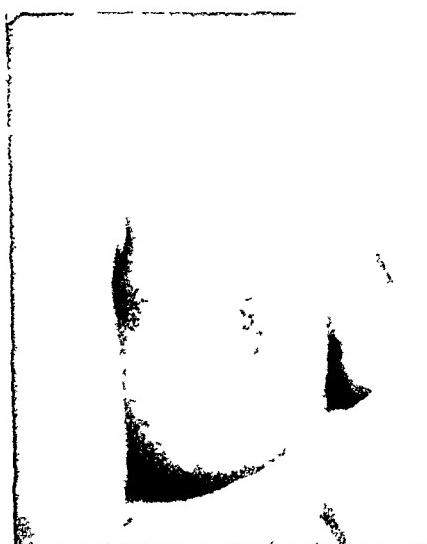


FIG. 5. Same patient as in Figure 3, three months after plastic reconstruction of the breast and nipple transplantation. Note complete pigmentation of nipple.

other normal components of the nipple. (Figs. 6 to 14. See also plate of microphotographs in color showing the various histologic elements of transplanted nipples.\*)

Dartigues,<sup>11</sup> of Paris, was first to adopt my method and popularize it on the

\* I am indebted for the histologic studies of the transplanted nipple tissue to Professors Maurice Oppenheim and Walter Schiller.

European continent. Others have been equally impressed with the advantages of the uncomplicated procedure as compared

the intervening twenty-five years have only added proof upon proof that properly transplanted nipples do unite to subjacent



FIG. 6. Transplantation of nipple three months after operation; Van Gieson stain; low magnification; E, epithelium; N, nerve.

with the frequently mutilating and scarring results of multiple operations.

In this connection may it be stated that Professor Axhausen in 1926,<sup>12</sup> in evaluating the various plastic operations on the breast, questioned the fate of transplanted nipples by my method and said: "If this important question could be answered in the affirmative, it would then certainly be better to resort to Thorek's operation than to court a possible necrosis of the nipple, should there occur a mishap by reason of a technical error in performing a Lotsch (transposition) operation." The recorded successes during

structures. Besides the microscopic proofs I am submitting additional clinical proof that should unreservedly confirm my original contentions. (Figs. 15, 16 and 17.)

*An Evaluation of Reconstructive Surgery of the Female Breast.* At a time when the art of the surgeon's hand has been devoted with the greatest possible skill to effacing the mutilations wrought by War and congenital malformations, it would seem hardly necessary to discuss the justification for and the evaluation of reconstructive surgery of any part of the human body. If improvement in personal appear-

ance were the sole reason for the plastic surgery under discussion, it would still be justifiable and in the same category

disfigurement and to minimize the embarrassment and revulsion in those brought in contact with such individual.

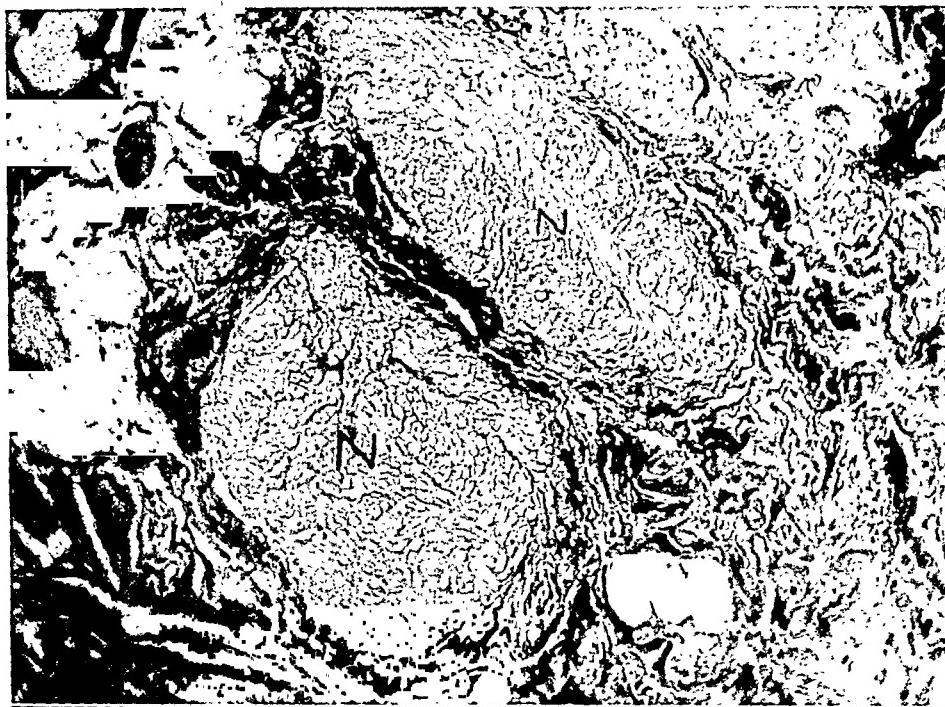


FIG. 7.

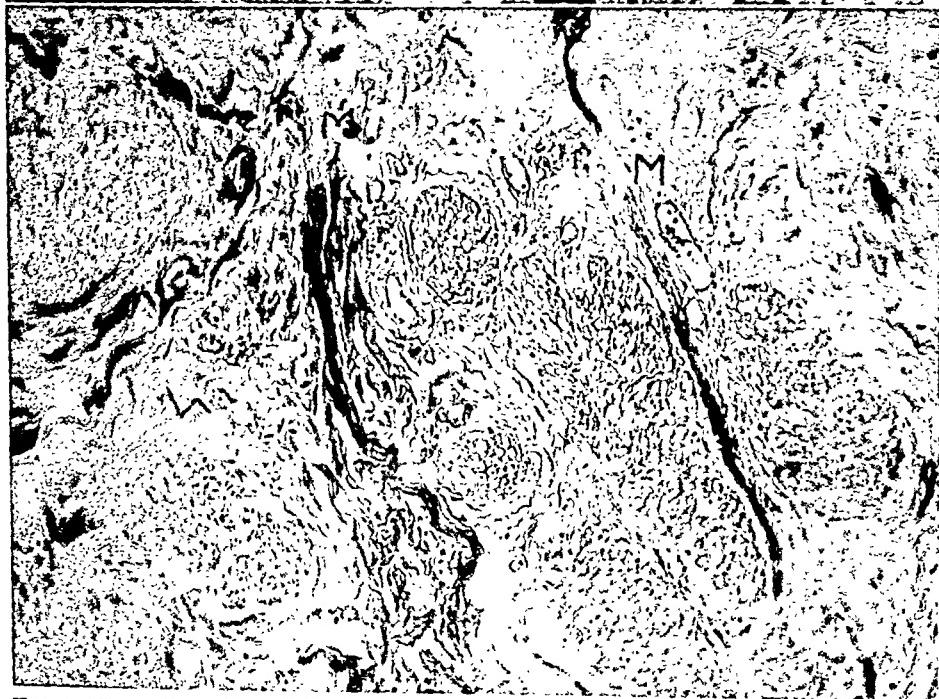


FIG. 8.

FIG. 7. Transplantation of nipple three months after operation; Van Gieson stain; magnification  $150\times$ ; NN, nerves.

FIG. 8. Transplantation of nipple three months after operation; Masson stain; magnification  $130\times$ ; M, muscle fibers in longitudinal section.

with skin plastics and tissue grafts of various kinds used to lessen the embarrassment of the unfortunate bearer of the

Pendulous and enormously hypertrophied breasts may be definitely responsible for much physical and mental suffer-

ings. This is particularly manifested in persons whose occupations bring them in contact with the public (business women, inferiority complexes. Kyphosis frequently results from an attempt of the patient to equalize the weight produced by the

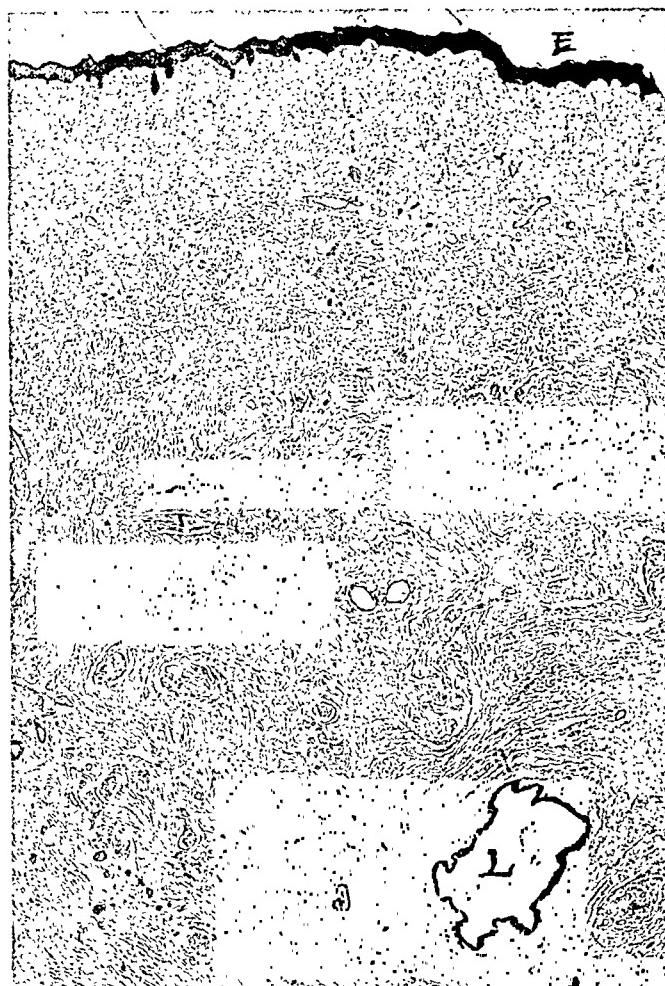


FIG. 9. Transplantation of nipple nine months after operation; Van Gieson stain; low magnification; E, epithelium; M, muscle fibers; L, lactiferous duct.

speakers, singers, artists, etc.). They frequently suffer keenly both mentally and physically. Certainly enormous deposits of fat are a deformity and physical handicap which hinder locomotion and exercise. (Figs. 18, 19 and 20.) They represent diseases of an endocrinic, metabolic and other functional origin. The excessive weight frequently causes circulatory disturbances and impeded lymph circulation followed by a chain of complaints of greater or lesser severity, drawing pains, backaches, oppression, tension, intertrigenous eczema, psychic depression and a chain of in-

pendulous breasts through constant bending backward. Sometimes ulcerations occur and even tumor formation. Certainly with the removal of such excess tissue, the amount of tissue subject to the possibilities of neoplastic transformation is reduced.

If for any reason or combination of reasons the operation is indicated, it is surely justifiable to perform such operation cosmetically and to leave a natural and pleasing, instead of an ugly appearance, especially as this can be done without increase in risk or even added inconvenience to the patient.

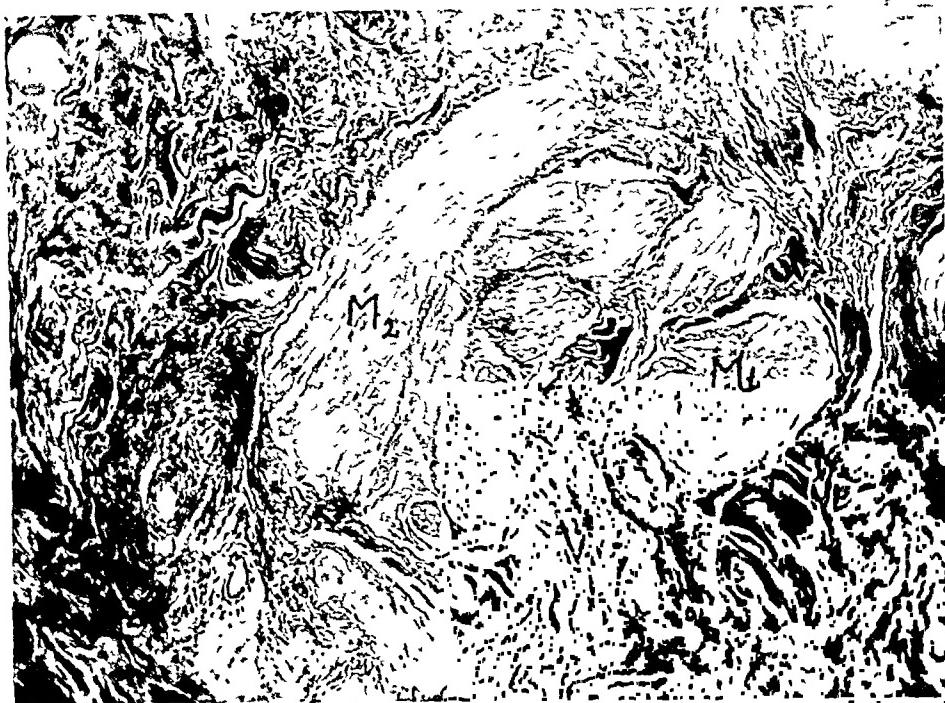


FIG. 10.



FIG. 11.

FIG. 10. Transplantation of nipple nine months after operation; Van Gieson stain; magnification 150 X; M<sub>1</sub>, muscle fibers in cross section; M<sub>2</sub>, muscle fibers in longitudinal section.

FIG. 11. Same as Figure 10, showing muscle fibers in cross and longitudinal sections, stained with Masson stain.



FIG. 12. Transplantation of nipple nine months after operation; elastic fiber stain; low power magnification; E, epithelium; S, sebaceous gland.



FIG. 13. Transplantation of nipple nine months after operation; elastic fiber stain; magnification 150 X; S, sebaceous gland; H, hair shaft; E, elastic fibers.

*Pertinent Considerations—Anatomic, Physiologic and Pathologic.* The causes of enlargement of the breasts are accumula-

son<sup>13</sup>). Geschickter<sup>14</sup> states that in the diffuse virginal hypertrophy which occurs during adolescence, the mammary en-



FIG. 14. Transplantation of nipple nine months after operation; hematoxylin-eosin stain; L, lactiferous duct of mammary gland; E, epithelium.

tions of fat, insufficiency of the suspensory apparatus and, to a minor degree, hypertrophy of the glandular structure. Usually the excessive accumulation of adipose tissue and the glandular component play the predominating rôle. Some authorities are of the opinion that the fat accumulated in hypertrophied breasts differs in composition from ordinary adipose tissue.

Excessive and persistent enlargement in one or both breasts may occur during adolescence or with pregnancy (Nathan-

large)ment begins about the time of the first menstrual period in the majority of cases, although abnormal growth may occur prior to the onset of menstruation. The enlargement usually progresses rapidly for a period of three to six months. This tremendous overgrowth of the mammary gland is apparently dependent upon the increased sensitivity of the mammary tissue to hormonal stimuli. Hypertrophy may occur at any time, the endocrines and genital function playing an important rôle.

Küster once saw a patient in whom hypertrophy of the breasts followed irradiation of the pelvic organs after an abortion.



FIG. 15. Virginal hypertrophy of the breasts.



FIG. 16. Same patient as in Figure 15 two weeks after operation showing a satisfactory healing of nipple with beginning desquamation of uppermost layer (stratum corneum) of nipple surface. Note the new nipple underneath in satisfactory healing process.

Virginal hypertrophy of the breasts must be distinguished from adipose breasts or the changes which may occur in cases of pituitary disturbances. In the latter cases there is an increase of fat about the hips

and in the mammary gland, but is not as excessive as in virginal hypertrophy.

Endocrine and other physiologic influ-

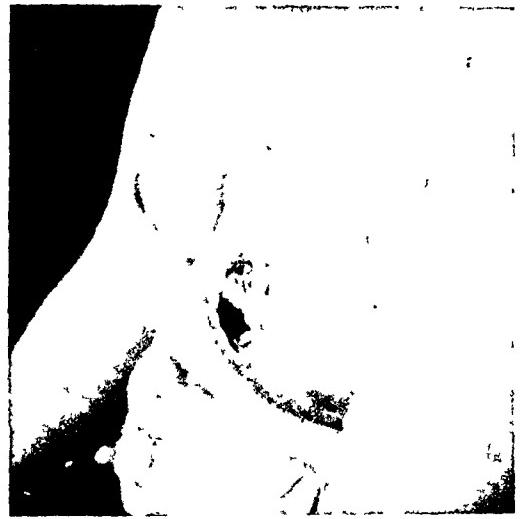


FIG. 17. Same patient as in Figures 15 and 16 three and one-half weeks after free transplantation of nipple. Note almost all of the stratum corneum has been cast off and the new nipple structures are shown.



FIG. 18. "Pancake breast"; insufficiency of suspension apparatus.

ence may produce changes that are not uniform throughout the breast. Marked differences may be found in different lobes of the same breast. The dependence of postnatal mammary development upon ovarian function is emphasized by endocrine studies. The estrogen secretion of the

ovarian follicle plays an important part in adolescent development and, with sexual maturity, both estrogenic and luteal hor-

essential, moreover, for the response of the mammary gland to the ovarian hormones. Testicular and adrenal cortical hormones



FIG. 19.



FIG. 20.

Figs. 19 AND 20. Examples of marked hypertrophy of the breasts causing physical distress.

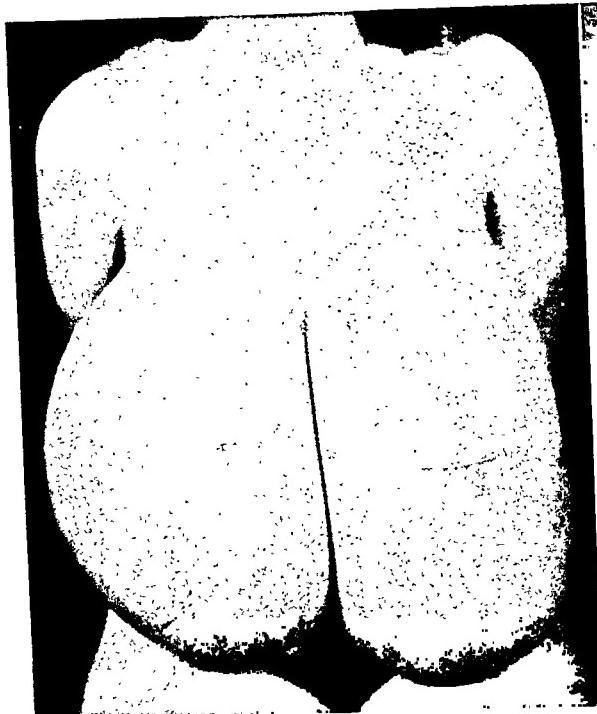


FIG. 21. Virginal hypertrophy of the breasts. Note lobular tumor in left upper quadrant of the left breast.

mones combine to produce physiologic changes. The anterior pituitary gland hormones are important not only to stimulate and maintain ovarian function but also to activate lactation. They seem to be



FIG. 22. Same patient as in Figure 21, lateral view.

may also induce changes in the mammary gland.

#### CASE REPORT

O. B. A young woman eighteen, started to menstruate four years previously, every other month. For the last year she has been

gaining weight due to increase in size of the breasts, which was especially rapid for the past six months. (Figs. 21, 22 and 23.) The

enlargement of both breasts, the left breast measuring 15.5 by 11 by 5 inches; the right breast measuring 15 by 11 by 4½ inches. The



FIG. 23



FIG. 24

FIG. 23 Same patient as in Figures 21 and 22, patient is reclining.  
FIG. 24 Gross appearance of breasts of patient in Figure 23 after removal, note tumor in center of field.

preoperative diagnosis was massive liposarcomatosis of both breasts.

The operation was done in two stages. Following removal of the enormous breasts, both nipples were transplanted to properly prepared beds, but because of threatened shock further operation on the right breast was postponed. Eight days later the operation on the right breast was completed and the patient made an uneventful recovery.

The pathologic report by Dr. Paul D. Szánto was as follows: Macroscopic: Symmetrical

weight of the left breast was 31 pounds; of the right breast 32 pounds.

The skin covering the breasts presents a thickening of the epidermis and derma. The nipples are not very prominent. The skin is somewhat wrinkled. On the cut surface of the subcutaneous fat tissue there are several distinctly encapsulated tumors present which are prominent and have a greyish cast. (Fig. 24.) A third small specimen taken from the axilla measures 3 by 2 cm which on the cut surface shows a greyish color.

*Microscopic Examination:* For microscopic examination, ten blocks were taken from different parts of the breasts, including blocks from

specimen of the axilla reveal also an identical picture. (Figs. 25 to 29.)

*Diagnosis:* Virginal hypertrophy of the

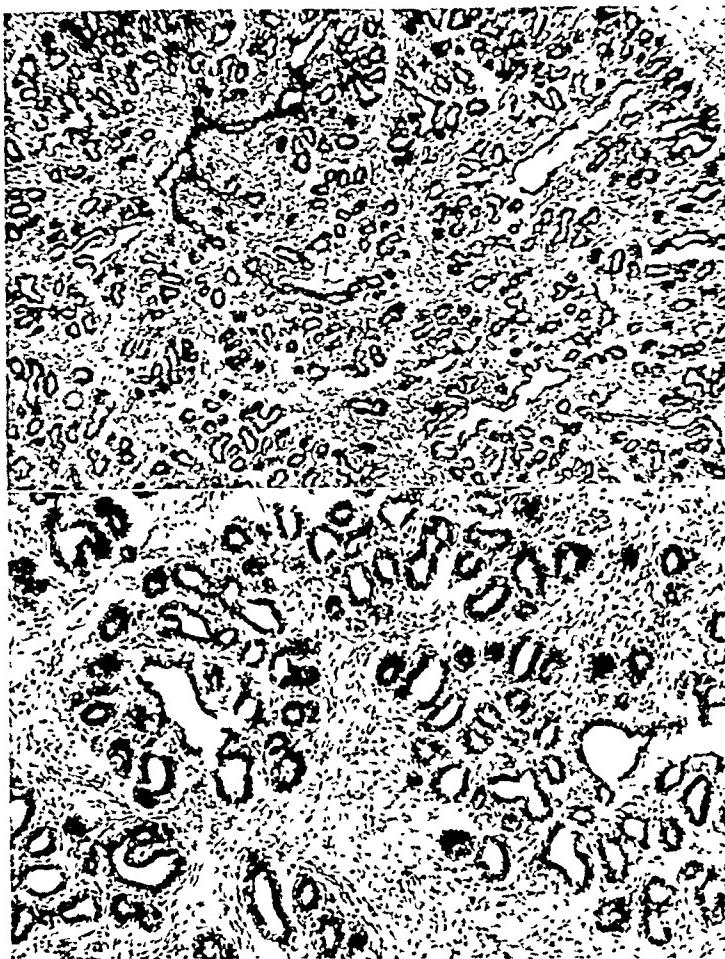


FIG. 25.

FIG. 25. Virginal hypertrophy of the breasts; marked lobular development of the breast gland and proliferation of interlobular connective tissue.

FIG. 26. Same as in Figure 25. The lobules are very distinct; the proliferation of the interlobular connective tissue is marked and very cellular ( $\times 80$ ).

the encapsulated tumor and from the specimen taken from the axilla. The microscopic sections showed a uniform picture in the sections of the blocks taken from the different parts of both breasts. The histologic picture is characterized by a marked hyperplasia of the lobular tissue. The perilobular and the periacinous connective tissue is cellular and loose. Some of the ducts are dilated and some of these are filled with degenerated débris. Both the larger and smaller ducts show proliferation of the epithelial cells. The encapsulated tumor presents exactly the same histologic picture as the breast tissue between the tumors. Sections from the

mammae, with multiple fibroadenomas and hypertrophy of the accessory breast gland in the axilla; no signs of malignancy.

*Comment.* The microscopic picture of diffuse virginal hypertrophy is characterized by a duct hypertrophy with marked proliferation of the periductal fibrous tissue. In the case here reported, the breast tissue showed also a marked hyperplasia of the lobular tissue which is somewhat unusual for virginal hypertrophy. However, a similar case, with almost identical

histologic findings has been reported by Geschickter in his monograph.<sup>11</sup> The combination of virginal hypertrophy with

tion of interlobular and periductal connective tissue. In the second part of the menstrual cycle, the hormone of the corpus

FIG. 27.

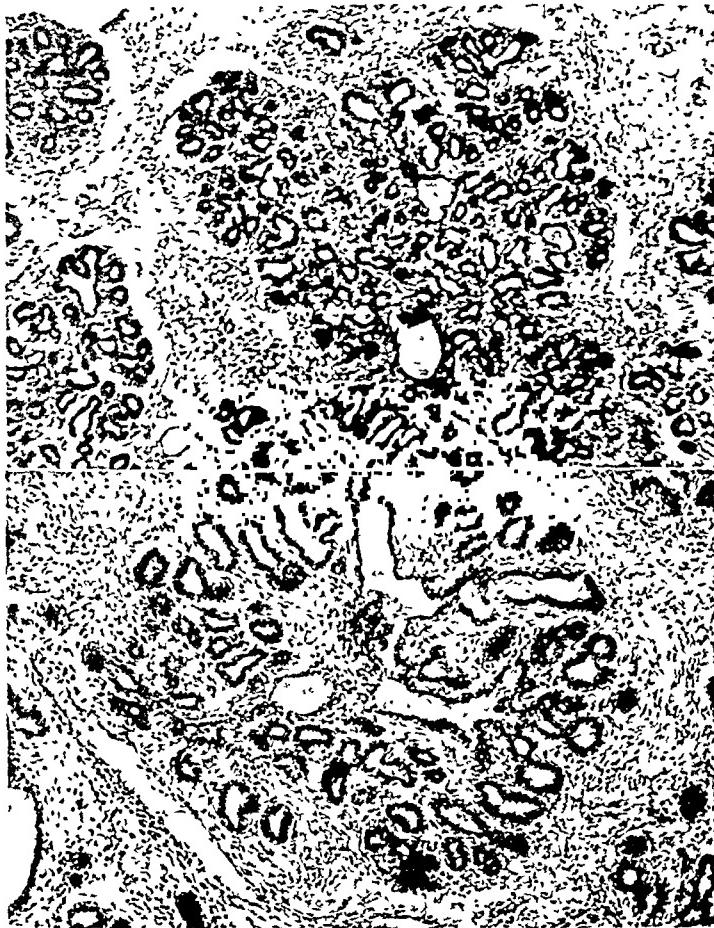


FIG. 27. Distinct lobular arrangement; some of the ducts are markedly dilated ( $\times 60$ ).

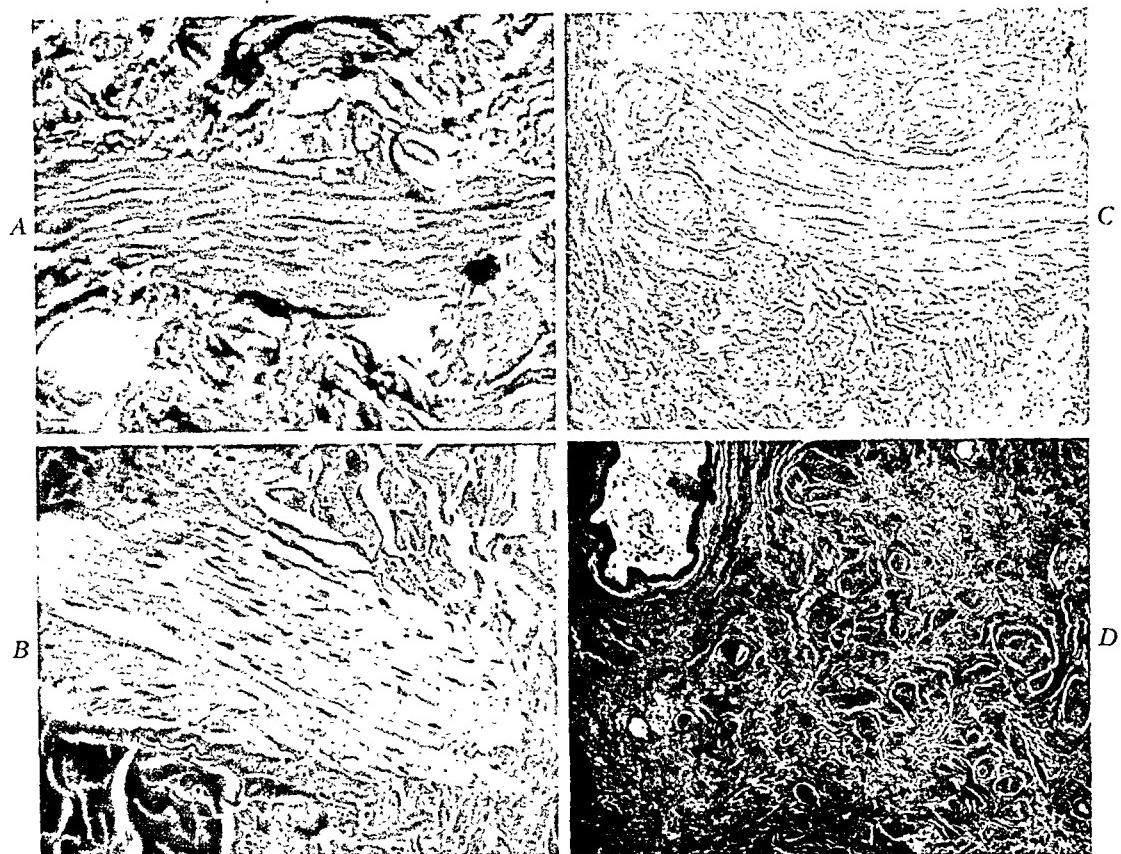
FIG. 28. This microphotograph represents one lobule, consisting of distended duct. The inter- and intralobular connective tissue is very cellular ( $\times 80$ ).

fibroadenoma is not unusual. It has been reported by Johnston and Bloodgood.<sup>30</sup> It is explained as a localized response on the part of one or more segments of the breast to an increased hormone production of the ovaries.

Because of the marked hyperplasia of the lobular tissue, there is a possibility of an increased pregnandiol production. It may be recalled that the breast shows marked cyclic changes under the influence of ovarian hormones. In the first two weeks of the menstrual cycle the estrin production of the ovary will result in a proliferation of the products, with prolifera-

luteum, the so-called pregnandiol, influences the proliferation of the acini.

In our case, the results of the endocrinologic examination were disappointing. In the twenty-four hour urine specimen we found between five to ten international estrin units, which represents the lower level of the normal. The pregnandiol determination was made just before the irregular menstruation of the patient started, which is the best time for such determinations. No pregnandiol could be found, however, in the urine. The negative results of these hormone determinations do not, however, rule out a disturbance of



Microscopic sections of transplanted nipples showing the presence of nerves, muscle and milk ducts (see also microphotographs in monochrome in text).

A. Nerve tissue. Mallory stain. High power magnification. Bundle of nerve tissue stained red running transversely across field. Tissue stained blue, represents fat.

B. Muscle tissue. Van Gieson stain. High power magnification. Here the muscular tissue is stained yellow, but the nuclei appear brown. Brick stained tissue surrounding muscle represents connective tissue.

C. Muscle and nerve. Masson stain. High power magnification. Here transversely running muscle bundles are seen stained a light green color. Structures as seen in cross section are nerves. On the left below the cross section of a nerve bundle the cross section of a blood vessel is seen.

D. Galactophorous duct. Van Gieson stain. To the left a milk duct is seen in longitudinal section. Numerous blood vessels, capillaries and nerves, as well as connective tissue compose the rest of the field.



the ovarian function. The functional disturbance of the ovary may last several months or years, or may disappear, and

months ago, the patient did have an ovarian disturbance, which, however, has now disappeared.

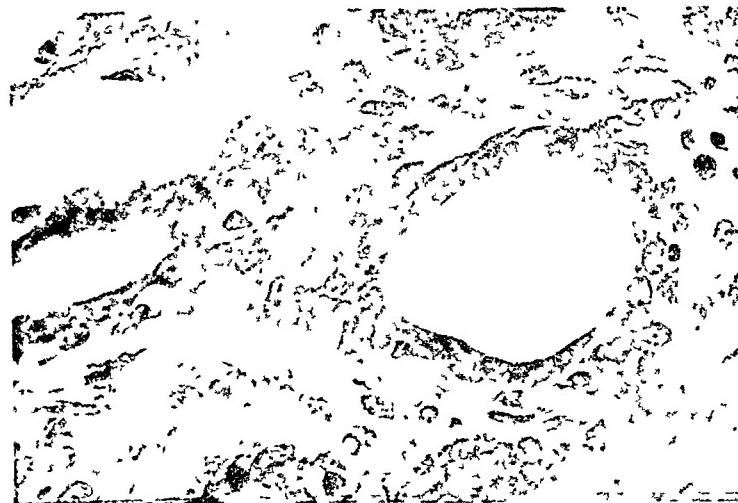


FIG. 29. This microphotographic enlargement presents two acini lined by cuboid epithelium. The vesicular nuclei of the intralobular connective tissue are clearly visible.



FIG. 30. Marked degree of virginal hypertrophy of the breast with "pancake" compression in the upper segment.

after its disappearance the morphologic precipitation of the ovarian dysfunction may remain. Applied in our case, we may say that there is a probability that several

An understanding of the nature of the suspensory apparatus of the breast is important in these enormous hypertrophies of the breast. This suspensory apparatus

is not always found as described in textbook diagrams. The suspensory arrangement of the breast was first described by

the breast where it divides into an anterior and posterior sheath which envelopes the breast. It is on this basis that the move-

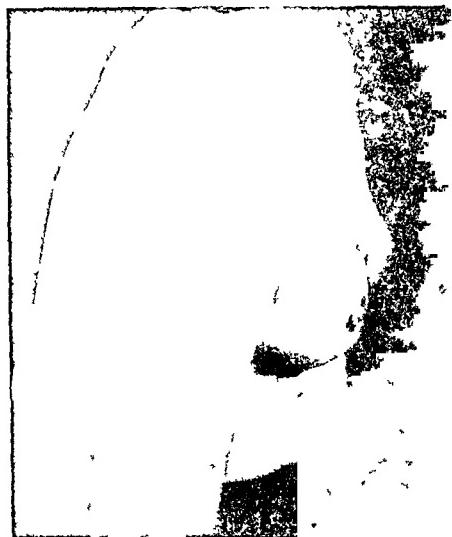


FIG. 31 Same patient as in Figure 30 after operation. Note desquamation of uppermost layer (stratum corneum) of nipple with normally healed nipple structure underneath.

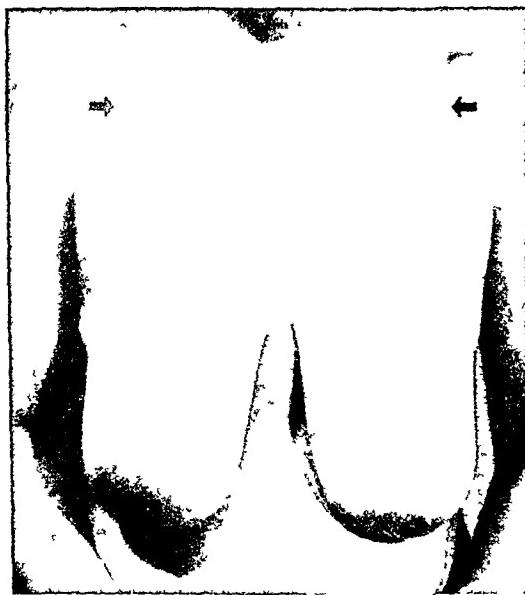


FIG. 32 Breast hypertrophy, patient complained of pulling sensations, and from pressure symptoms of brassieres. Note arrows pointing to impressions from the straps.

Sir Astley Cooper. Giralde speaks of a *ligamentum suspensorium mammae* which forms a special division of the superficial thoracic fascia, beginning at the clavicle and extending to the superior border of

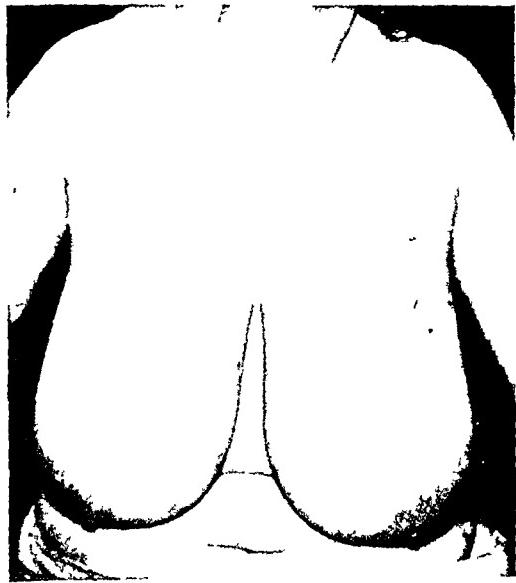


FIG. 33. Virginal hypertrophy of the breasts



FIG. 34. Same patient as in Fig. 33; lateral view.

ments of the breast are synchronized with those of the shoulder girdle. Testut (cited by Girard) observed that this suspensory ligament is at times well developed and at others just slightly indicated. It is most pronounced on the posterior surface of the

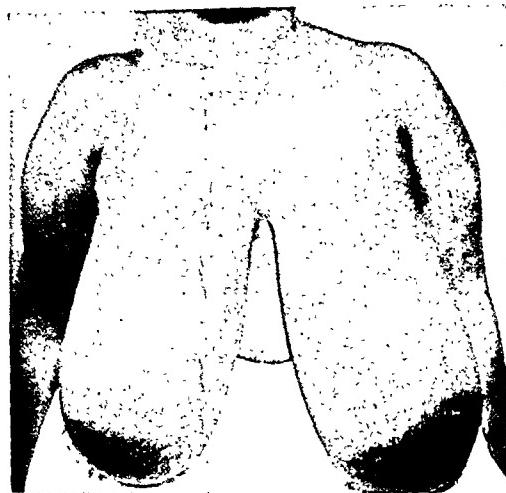


FIG. 35. Virginal hypertrophy of the breasts causing interference with functions. (Author's Service, Cook County Hospital, Chicago, Illinois.) Before operation.

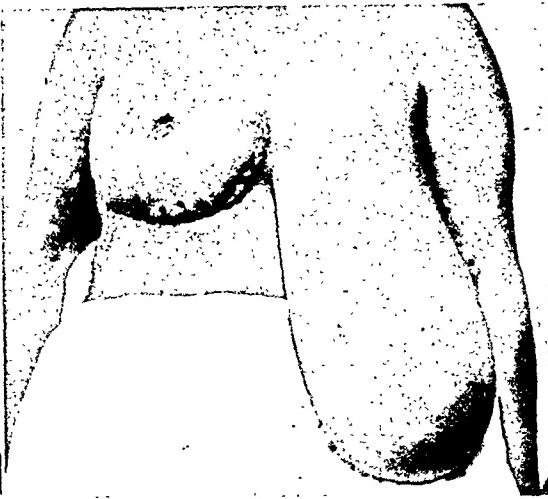


FIG. 36. Same patient as in Figure 35 after one breast had been operated upon by the author's method (free transplantation of the nipple and mammoplasty).



FIG. 37. Virginal hypertrophy of the breast, before operation. Note tremendous enlargement of breast and venous engorgement. The breasts descend to the level of or a little lower than the umbilicus. In a sitting position the breasts are below the umbilical area. The outlines on the breasts are guides for the incision in the formation of the anterior flaps.



FIG. 38. Same patient as in Figure 37 twelve days after operation. Note discoloration of nipple which is only temporary affecting the uppermost layer (stratum corneum) of the nipple. This becomes desquamated and a nipple of normal color is exposed.

breast, but in practice is sometimes difficult to demonstrate. Küster believes that the principal factor in suspending the



FIG. 39. Patient shown in Figures 37 and 38 three weeks after operation. Note progressed desquamation of stratum corneum.

breast is the skin covering it, which sends into the gland structures, fibrous tissue septa in a comblike manner. The posterior surface of the breast is connected to the pectoral muscle by means of a layer of very loose areolar tissue, which permits greater mobility. This plays a minor rôle in suspending the breast.

It is apparent that the weight of a large accumulation of fat and fibrous tissue in the breast so stretches the suspensory apparatus that the breast descends and prolapses, the degree depending upon the degree of tissue accumulation. In some instances the breasts have reached below the umbilicus. Hypertrophy of the breasts is often observed while the rest of the body remains in perfectly normal proportions. Loss of weight through diet and medical means may, on occasion, be effective in reducing the breasts. However, this usually fails and creates an unesthetic condition of flap-like skin bags, which I have described as "reduction bags." (Fig. 18.)

The blood supply plays a very important role in plastic surgery of the breast. Necrosis may result if the branches of the in-



FIG. 40. Breast pendulosity; so-called "pancake" breast, the result of compression for many years with tight fitting brassieres. Multiple stage operations do not, as a rule, yield good results in these cases. Satisfactory results are obtained by simple plastic reconstruction of the breast. (Lotsch, Kraske, etc.)

ternal mammary artery are encroached upon, of, if on the lateral aspect, vessels entering the breast from the axillary line are injured. Ansom, Wright and Wolfer<sup>15</sup> summarize their discussion of the blood supply of the mammary gland: "(1) The mammary gland receives its blood supply from two chief sources, namely, the anterior perforating branches of the internal mammary artery, and the mammary rami of the axillary artery itself or one of its main stems. (2) The mammary rami of the anterior perforating arteries form a transversely arranged series, extending from the first to the fourth intercostal spaces. (3) The mammary branches of the axillary artery leave the axillary fossa together; accompanied by the corresponding veins they form a small 'pedicle' of vessels. (4) Upon the breast the mammary vessels occupy the most superficial level of the fatty tissue, being virtually subcutaneous in position. (5) From these various mammary rami smaller twigs are given off, at a right angle, into the substance of the gland; the more prominent of these are

traceable into the mammary tissue to a depth of approximately 2.5 centimeters. (6) Both upon the surface of the gland,

pathetic innervation is not well described, although its rôle seems quite well known. It is capable of exciting the nipple reflex

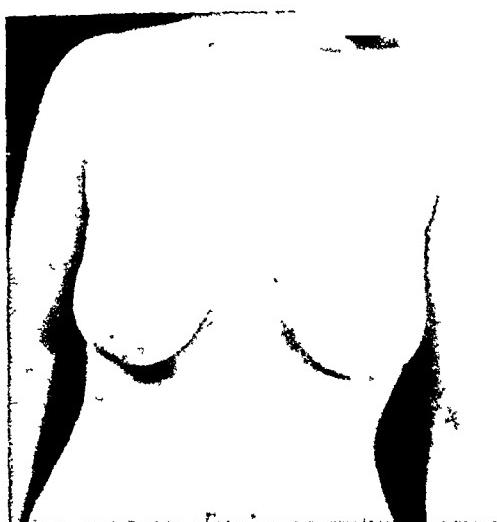


FIG. 41. Mild degree of mastoptosis; in such cases the Lotsch operation may be done.

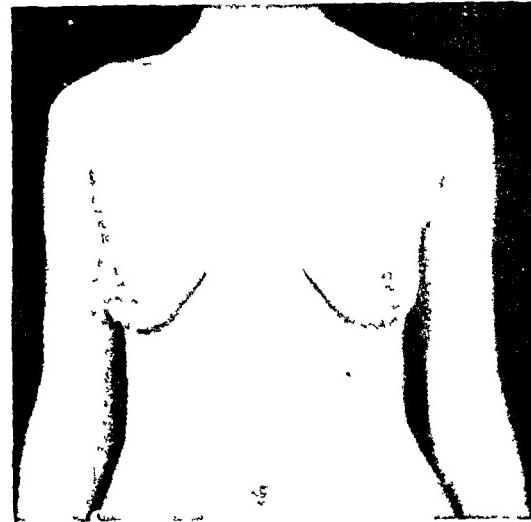


FIG. 42. Here also the Lotsch procedure may be attempted.

and within its substance, anastomotic communications between neighboring rami are common. (7) None of the so-called medial mammary branches of the anterior intercostal arteries pierce the pectoral musculature to reach the overlying mammary gland; they terminate as muscular branches, leaving the deep or thoracic aspect of the gland devoid of arteries of gross proportions. (8) Similarly, none of the pectoral rami of axillary derivation pass from the deep level through anterior pectoral muscles to supply the mammary gland. (9) No vessels reach the gland from the inferior aspect; they approach the gland only from the medial and the superolateral aspects."

From the surgical viewpoint, Wolfer says: "Plastic procedures which are designed to elevate a large pendulous breast can be carried out with comparative safety so far as the blood supply is concerned, since there exists inferiorly an area in which vessels are few in number. For this reason, also, excision of breast tissue should be made from the inferior, not from the superior portion."

The nerves of the mammary gland have been studied by Eckhardt. The vagosym-

and may regulate the galactogenic hypophysary secretion. The reflex follows the sensory path because experimentally and clinically it has been observed that the interruption of the motor path does not cause any disturbance in the reflexes.

As to the function of the breasts, it is well known that hypertrophied breasts are of little value as far as lactation is concerned. Such breasts are, as a rule, functionally inactive organs. It has been noted by many authors that women with hypertrophied breasts who have given birth to children often find that they are unable to nurse them (Girard). Thus the impression that large breasts denote good function is not based on fact. If after reconstructive operations on the breast the lactophorous function is lacking, it would seem that no great change in this respect has been suffered. Some instances have been recorded in the literature of pregnancy and lactation occurring after plastic surgery on the breast, but no promise of such result can be held out to the prospective patient.

Instances have been noted in which improvement in the general condition of the patient has occurred, and especially

in those conditions generally associated with greatly enlarged and pendulous breasts, after a considerable portion of the breast

The ideal results one aims to accomplish in plastic reconstruction of the breasts are: (1) The newly reformed breasts must

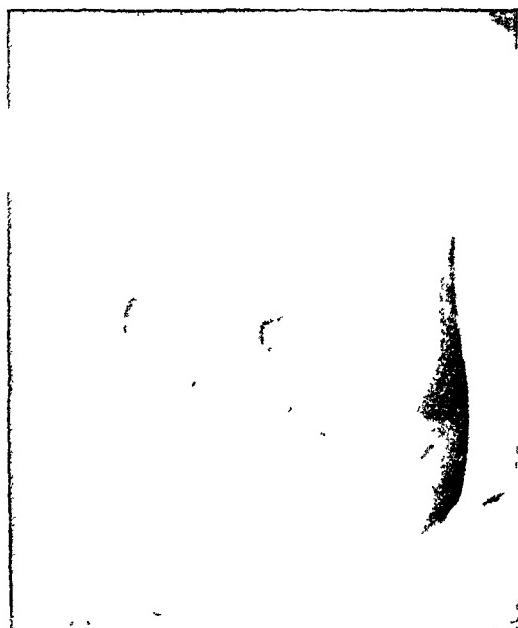


FIG. 43. Results in mild degree of mastoptosis from the Lotsch transposition of the nipple operation.



FIG. 44. Unfortunate results of an attempt by an inexperienced operator to do a plastic operation on the breast. Note necrosis of the breast tissue and transplanted nipple in the axilla. From Thorek's "Plastic Surgery of the Breast and Anterior Abdominal Wall," courtesy of Charles C. Thomas.

substance has been removed, although it may be difficult to explain the connection between the operation and such improvement



FIG. 45. Same patient as in Figure 44, displaying the other breast. Note total necrosis of the nipple, sloughing and infection in the lower segment of the breast. From Thorek's "Plastic Surgery of the Breast and Anterior Abdominal Wall," courtesy of Charles C. Thomas.

be situated in their normal position. (2) They must be able to function (endocrinologically). Enough tissue is left behind in a properly performed reconstruction operation to assure endocrine function. (3) The breasts must have the form and size of the normal breast and no injury to the blood and lymph vessels must result. (4) The scars should be as inconspicuous as possible. (5) Both breasts should be symmetrical. All of these results can be achieved by proper technic. (Figs. 30 and 31.) Types of breasts in which author's operation yields gratifying results are shown in Figures 32 to 38.

Reconstruction operations on the pendulous breasts may be divided into four principal types: (1) Procedures aiming to suspend the breast (after proper dissection)

to the costal cartilage of the second and third rib (Girard). (2) *Transpositions* of the nipple with remodelling of the breast tissue (Lotsch, Kraske, Axhausen and others). (Figs. 40 to 43.) In minor degrees of prolapsus the Lotsch operation may be resorted to. In more pronounced cases such operations will often prove unsuccessful. (3) The third variety, of which the Lexer-Hollander and Joseph operations are representative, consist of an incomplete detachment of the connections between the breast, nipple, and skin-covering, followed by reconstruction of the form of the breast by excision of the required amount of tissue, and finally by proper flap placements. These are the two-stage and occasionally *three-stage operations* (Joseph). The results are often not satisfactory from an esthetic point of view.

The conscientious surgeon will familiarize himself thoroughly with all recorded technics. In plastic reconstruction of the female breast, it is not sufficient to possess an accurate knowledge of anatomy and physiology; such knowledge must be supplemented by special surgical training. Furthermore it is essential that the surgeon possess a definite sense of innate artistry, because this type of surgery represents the highest degree of surgical sculpture, if such term be permitted. The patient has a right to demand the very best possible esthetic result. Only by giving these distressed and often despairing individuals the consideration to which they are entitled and offering to them the benefits of plastic surgery at its best can the charlatans and imposters be excluded from a field which lay undeveloped and discredited for too long a time because of their failures and the resulting disfigurements.<sup>31</sup> (Figs. 44 and 45.)

This discussion of plastic surgery of the female breast would be incomplete without a mention of the underdeveloped breasts in which derma-fascia transplants may be used to advantage.<sup>16</sup>

There are, of course, contraindications to plastic surgery of the breast. Among them are pulmonary, cardiac, renal, and

metabolic diseases. A definite contraindication is a surgeon not specially trained in reconstructive surgery. Under no circumstances should the operation be undertaken unless specifically indicated and no contraindications exists, and unless the surgeon be thoroughly qualified to perform it.

#### SUMMARY

1. Twenty-five years of experience with plastic reconstruction of the breast with free transplantation of the nipple, an operation devised by the author, are described and evaluated.
2. In minor degrees of prolapsus of the breasts, the Lotsch operation may be resorted to.
3. In marked prolapsus and in marked hypertrophies, the author's operation compared with other methods yields gratifying results.
4. The author offers additional proofs that the transplanted nipple survives.
5. Technical details and safeguards for avoiding failures are pointed out.

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MALIGNANT tumors of the breast grow more rapidly and are a greater hazard during pregnancy. In general, the younger the individual, the more rapidly a cancer of the breast will grow. This rapidity of growth makes the prognosis more grave in this group.

FROM "Operations of General Surgery" by Thomas G. Orr (W. B. Saunders Company).

# THE USE OF THIOURACIL IN HYPERTHYROIDISM\*

## TEN ILLUSTRATIVE CASES

ARNOLD S. JACKSON, M.D.

Diplomate of the American Board of Surgery

MADISON, WISCONSIN

THE introduction of thiouracil† in the treatment of hyperthyroidism has awakened greater interest in the field of thyroid surgery than there has been at any time since Plummer suggested the use of Lugol's solution in 1922. Although little more than a year has elapsed since Astwood<sup>1</sup> first reported the treatment of three thyrotoxic patients with this drug, several studies on this subject have appeared in the literature. The majority has enthusiastically endorsed the use of thiouracil; but the fact that agranulocytosis has occurred in a number of cases, in at least seven of which there have been fatal results, demands a careful clinical and laboratory study before releasing the drug for general distribution. The 1,300 and more deaths from agranulocytosis occasioned by the use of the various amidopyrine compounds are still too well remembered to occasion a similar tragedy.

The Lederle Laboratories, distributors of Deracil (thiouracil), have been conducting an intensive pharmaceutical and clinical investigation of the drug during the past two years. In a recent communication Dr. S. M. Hardy,<sup>2</sup> assistant medical director of Lederle, advises that thiouracil has now been used in nearly 2,000 cases, the results in approximately 84 per cent being beneficial. He states that despite the seven fatal cases of agranulocytosis the medical consensus is that this drug is too valuable for the control of thyrotoxicosis to be discarded because of occasional, although admittedly serious, toxicity. As

a consequence, Lederle has decided to continue the laboratory and clinical investigations of the drug for at least the next twelve months.

In 1938, I urged the presidents of two leading pharmaceutical companies to stop advertising and to withdraw the use of their amidopyrine-containing sedative compounds. Several cases of agranulocytosis admitted to the Jackson Clinic had resulted fatally from the use of these preparations. In reply, one of these officials stated that it was very questionable if amidopyrine was an etiological factor and that the drug was too valuable to be withdrawn because an occasional patient might react unfavorably when it was beneficial to so many.

The case is somewhat different with thiouracil. A large number of persons die each year from the effect of toxic goiter, and many others are seriously incapacitated, some permanently. Any drug that might obviate the necessity for surgery or considerably lessen its hazards is worthy of our consideration. Dr. Hardy is proceeding most carefully in his study of the drug and has warned all who have been allotted thiouracil of its potential dangers. He believes that each case should be continuously and carefully watched for symptoms or signs of toxicity, particularly for leukopenia and agranulocytosis. He also believes that it is the responsibility of the individual investigator in each case to decide whether the employment of thiouracil is a greater risk than thyrotoxicosis untreated.

Although thiouracil has been available to me for over a year, I have formed no

† The thiouracil was supplied through the courtesy of the Lederle Laboratories, Inc., Pearl River, New York.

\*From the Freda Meyers Nishan Foundation for the study of goiter of the Jackson Clinic. Presented before the meeting of the Western Surgical Association, Chicago, Dec. 2, 1944.

definite conclusions as to its beneficial or harmful effects. It appears that at least another year must elapse and a consider-

nomatous goiter with hyperthyroidism responded equally well. He further observed that clinical improvement preceded



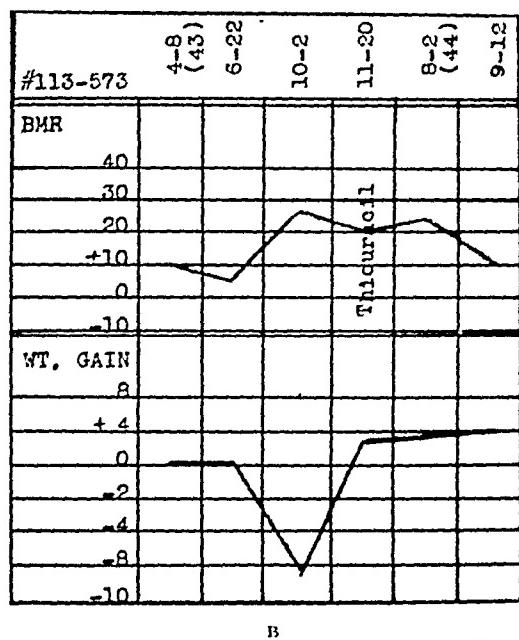
A

FIG. 1. Case 1. A and B, recurrent exophthalmic goiter with nerve paralysis controlled by thiouracil.

ably larger series must be studied before a proper evaluation of thiouracil may be ascertained. Probably my inability to achieve more brilliant results has been due to a hesitancy to subject many of my patients to what I considered an unnecessary risk. Undoubtedly, a quicker and more favorable response could have been obtained with considerably larger doses of the drug. Yet I have been surprised to read of the very large doses used in some cases which clinically suggested non-toxic adenomas.

#### STUDY OF THE CLINICAL REPORTS

Following Astwood's<sup>1</sup> report in 1943 of the use of thiouracil in thyrotoxic goiter, there appeared a study by Williams and Bissell<sup>2</sup> of nine similar cases that clinically responded favorably and showed a drop in the basal metabolic rate returned to a point at or near normal following the use of thiouracil. Twenty days to six months was necessary to accomplish this result. No ill effects were observed. Patients with either primary hyperthyroidism or ade-



B

a drop in the metabolic rate; that the gland remains the same in size and consistency; that thrills and bruits persist and that failure of the primary hyperthyroid gland to involute causes considerably more bleeding and technical difficulty at operation. Bartel believed that the preoperative use of thiouracil in severe hyperthyroidism did shorten the time of treatment, reduce the hospital stay (open to question), and limit the procedure to a subtotal thyroidectomy. Gabrilove and Kert<sup>3</sup> reported on the use of thiouracil in nine cases in three of which toxic reactions occurred. Paschkis<sup>4</sup> and his associates reporting in Endocrinology, May 1944, found in a study of twenty-one cases of thyrotoxicosis that the disease can be suppressed with either thiourea or thiouracil. The former proved to be more toxic and was discontinued.

Next, Williams and Clute<sup>7</sup> reported on the treatment with thiouracil of seventy-two patients with thyrotoxicosis, the majority of whom obtained a normal rate and remission of the disease. An average of five weeks was required to bring the

metabolic rate to normal in the severe cases and but three weeks in the mild ones (+15 to +35 per cent). Sixteen patients were

nized the growing interest and importance of this subject with an editorial in the September 16, 1944 issue. The editorial



FIG. 2. Case II. A and B, a severe case of iodine-fast exophthalmic goiter responding well to thiouracil.

treated for more than six months. In four patients who discontinued therapy after a few months a relapse occurred in about three weeks, but a remission was again obtained with thiouracil therapy.

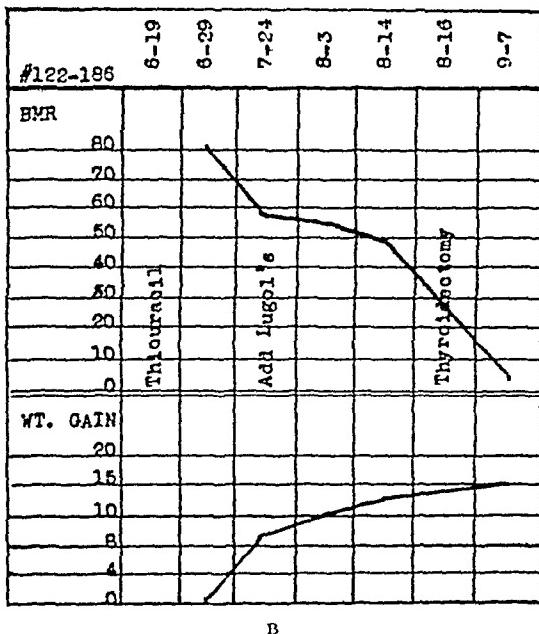
Great interest was manifest in the exhibit on thiouracil presented by Williams at the convention of the American Medical Association in June, 1944, at Chicago, and in recognition a silver medal was awarded.

Moore<sup>8</sup> and his collaborators concluded from a study of twenty-six thyrotoxic patients that thiouracil was superior to iodine in the preparation of patients for operation.

Then followed successive reports in the Bulletins of the McGregor,<sup>9</sup> Lahey,<sup>10</sup> and Jackson Clinics<sup>11</sup> on the experiences of these institutions with the drug.

Goldsmith<sup>12</sup> et al. suggested the use of liver or folic acid in the prevention and in the treatment of the thiourea induced granulocytopenia.

The American Medical Journal<sup>13</sup> recog-



concluded by saying that whether or not thiouracil will prove to be a satisfactory substitute for surgical treatment of toxic goiter cannot be stated on the basis of the present limited experience. The drug promises to be of great value in cases in which operation is inadvisable or contraindicated.

In the same issue of the journal appears a report by Reveno<sup>14</sup> of nine cases of toxic adenoma treated with thiouracil. Six showed a satisfactory response, and three were failures.

Kahn and Stock<sup>15</sup> reported a fatal case of agranulocytosis resulting from thiouracil.

Cannon<sup>16</sup> found that in two patients with hyperthyroidism treated with thiouracil there was marked improvement.

Clute and Williams<sup>17</sup> presented their study of this subject before the American Surgical Association meeting in May, 1944, and this paper appeared in the October Annals of Surgery. Their conclusion was that this drug is a valuable addition to our means of treating hyperthyroidism and for

preparing patients with this condition for surgery. The late results in the operative cases were excellent.

only 0.1 Gm. When several doses were given daily, they were spaced evenly. Within the range of the dosage employed,

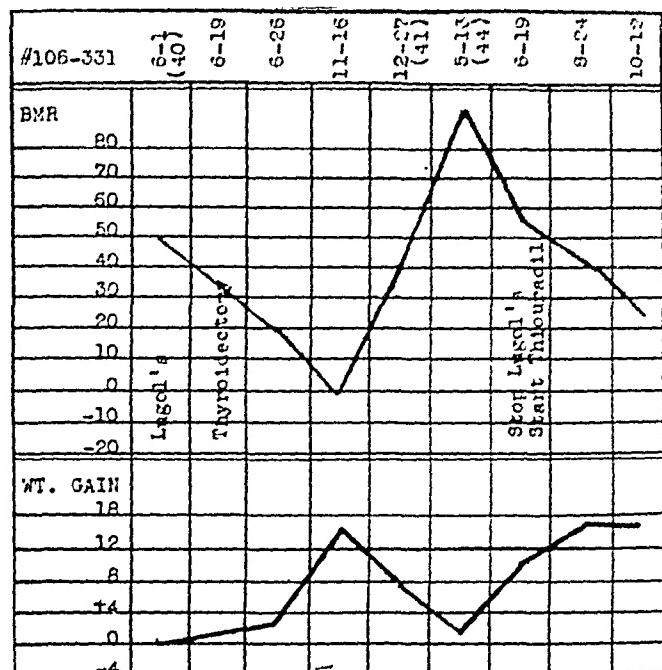
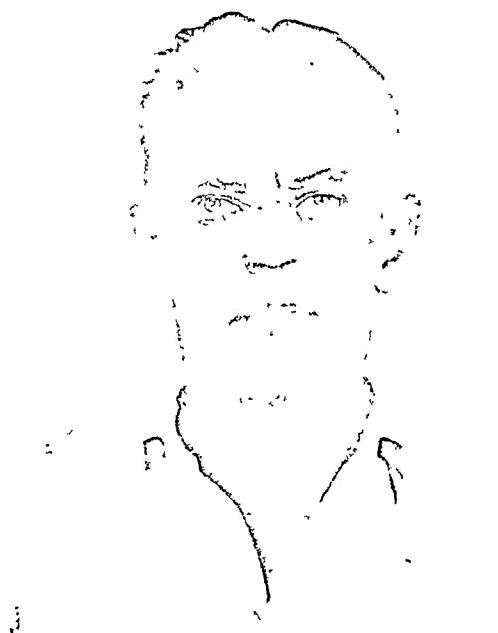


FIG. 3. Case IV. A and B, a recurrent case of exophthalmic goiter under control by thiouracil.

In the November issue of the Medical Clinics of North America appears an article on the "Treatment of Thyrotoxicosis with Thiouracil" by Dr. Karl E. Paschkis,<sup>18</sup> of Jefferson Hospital, Philadelphia.

This rather detailed summary of the clinical literature on this subject is, I believe, the first to be presented and is important because of the controversial points that have arisen, the number of fatalities that have occurred, and the need for further careful study and evaluation of this drug.

#### DOSAGE

In the first thirty patients treated by Clute and Williams<sup>7</sup> the initial dosage of thiouracil was usually 0.1 Gm., but with subsequent patients it was increased to 0.4 Gm. or 0.6 Gm. daily. In most cases, however, the dose was reduced to 0.2 Gm. daily over a period of about six weeks. Single doses usually consisted of 0.2 Gm. although they were sometimes

the drug has not been found to accumulate appreciably in the blood in spite of severe disease of the kidneys and liver.

There has been no uniformity of agreement as to the dosage. Thus Paschkis<sup>18</sup> found in most cases that 0.1 Gm. of thiouracil was effective, whereas Reveno<sup>14</sup> employed 0.8 Gm. and Bartels<sup>4</sup> observed no toxic effect from the daily dose of 0.6 Gm.

In my own experience I have been unable to standardize on any dosage, believing so far that each case must be judged individually depending upon age, duration and severity of symptoms, whether or not the patient has previously received iodine, the type of hyperthyroidism, et cetera.

In treating eleven year old children with rather severe primary hyperthyroidism and in treating several elderly persons with advanced, multiple, toxic adenomas, I have believed that a dosage of 0.6 Gm. or 0.8 Gm. carried a considerable risk and that it was safer to begin with

0.1 Gm. or 0.2 Gm. and gradually increase the dosage to 0.4 Gm., and then as soon as the hyperthyroidism was controlled,

The most common toxic manifestations as observed by Williams and others have been vertigo, headache, nausea, hyper-

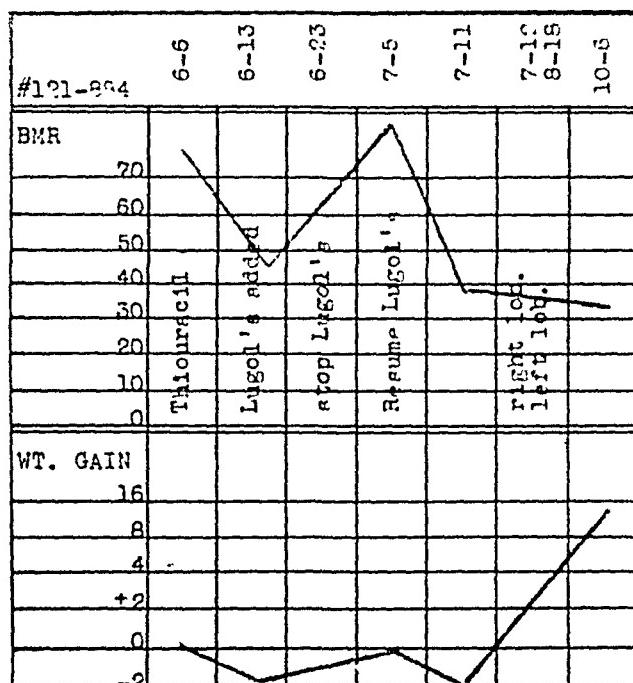


FIG. 4. Case v. A one-stage thyroidectomy was done on this patient with a severe case of exophthalmic goiter.

to again reduce the dosage. Very possibly with larger doses my results would have been more spectacular, but in this small series of cases, thirty now being studied, no serious reactions have occurred. It has always seemed to me that before testing any new medical or surgical procedure on anyone, the criteria should be whether we would employ a similar remedy or method on a member of our own family.

#### COMPLICATIONS

As yet nothing has appeared in the literature as to how long one may safely be kept on thiouracil except that Williams<sup>7</sup> has reported sixteen cases on the drug for six months (now perhaps a year). In the case of amidopyrine, certain persons were able to take the drug for months without developing agranulocytosis. Then after stopping a few weeks or months and resuming the drug, toxic reactions occurred. The same has been true of the sulfonamides.

pyrexia, morbilliform rash, pruritis, urticaria, allergic arthritis, edema of the legs, vomiting, enlargement of the submaxillary glands, leukopenia, agranulocytosis, and jaundice. Two questionable reactions have been observed in my series. Following the ingestion of 0.4 Gm. of the drug for two days, a middle-aged male with an exophthalmic goiter complained of severe abdominal cramps, nausea, and vertigo. The drug was stopped, but his disturbance could have been presumably due to other causes. A young girl with a severe, persistent hyperthyroidism despite thyroidectomy developed an unusual skin eruption, the hands and arms assuming a livid crimson color. However, after stopping the drug, the rash cleared up only to return ten days later. Again the drug may not have been responsible.

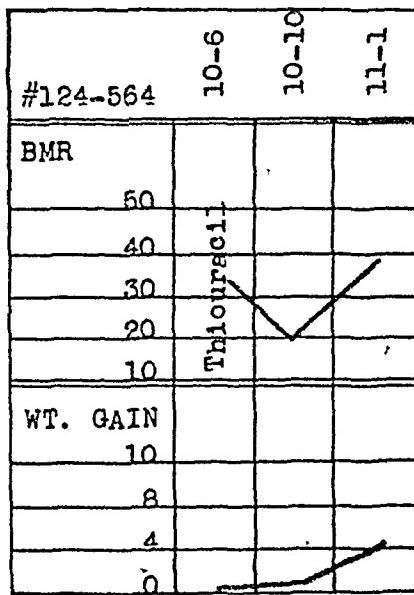
In order to protect our patients from agranulocytosis, it has been our plan to check the patient's white blood count as well as the general condition every two weeks. However, war time travel condi-

tions often make this difficult. Consequently, we have frequently extended this period to three and even four weeks.

was stopped. In one of the cases, the reaction was accompanied by swelling of the face, marked somnolence, muscular



A



B

FIG. 5. Case IX. A and B, a twelve year old child with exophthalmic goiter, now on thiouracil.

Under such conditions one must hesitate before using larger doses of the drug.

In a communication received from Dr. Robert Williams<sup>19</sup> on October 25, 1944, he states that about 210 patients with hyperthyroidism have now been treated with thiouracil and that the results have been essentially the same as previously reported. Complications were definitely less common in the second hundred cases. Two cases of agranulocytosis were observed, but the other complications have tended to be relatively mild.

William and Bissel<sup>3</sup> reported transient edema with depression of the carbon dioxide combining power of the plasma and elevation of the plasma chlorides. In his discussion of Dr. Clute's paper before the American Surgical Association, Dr. John de J. Pemberton<sup>17</sup> stated that a similar reaction had been observed at the Mayo Clinic in two patients to whom thiouracil was administered because of severe recurrent exophthalmic goiter. The reactions were so severe that the drug

twitching, myoclonic spasms, incoherent, slurred speech, vertigo, and severe headache. The reaction occurred on each of three occasions when the drug was given and twice when the basal metabolic rate was normal.

#### BENEFICIAL EFFECT OF THIOURACIL

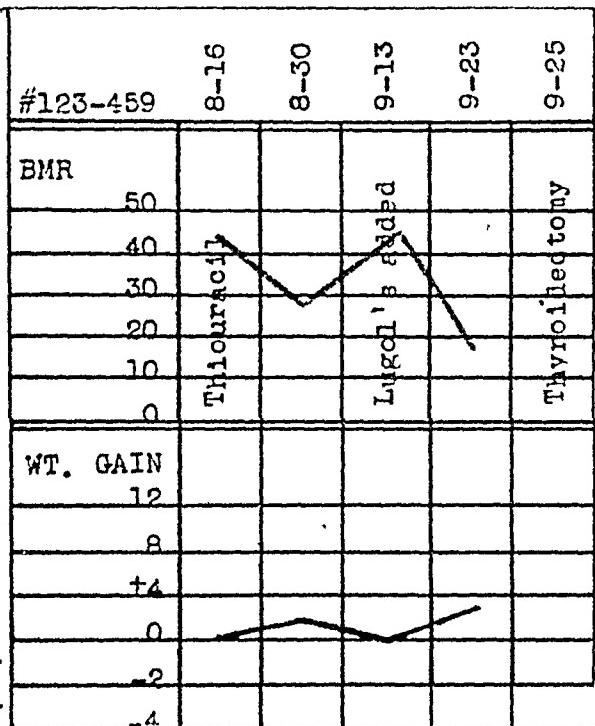
Considerable time and space have been devoted to the possible serious effects of thiouracil because it has seemed to me that this phase of the subject has not been sufficiently emphasized. Before considering the possible beneficial effects of this drug in hyperthyroidism, the special indications for its use might be evaluated. Its curative effect may be considered only from the standpoint of primary hyperthyroidism, as obviously it will not cause the disappearance of a multiple, toxic adenoma of the thyroid. Clute and Williams<sup>7</sup> go so far as to state that it is distinctly possible that surgery will in the near future be unnecessary in many patients with exophthalmic goiter. Hardy,<sup>2</sup> how-

ever, is of the opinion that the drug will prove especially useful for the preoperative preparation of patients rather than for

severe exophthalmic goiter in the very young and in the aged, in the debilitated, decompensated, et cetera; (4) cases of



A



B

FIG. 6. Case X, A and B, a patient with iodine-fast exophthalmic goiter prepared with thiouracil on whom a primary thyroidectomy was performed.

lifelong usage. It would indeed be a boon to mankind if exophthalmic goiter might yield to thiouracil rather than surgery, but from my small experience this is still a hope.

Pemberton<sup>17</sup> has expressed a doubt whether or not the surgical mortality in cases of exophthalmic goiter of moderate or slight severity, already nearly as low as in non-toxic adenomatous goiter, can be lowered by preparation with thiouracil rather than iodine. That doubt seems justified.

There remain the following groups of cases that might be benefited by thiouracil preparation where iodine has little effect: (1) Advanced cases of multiple toxic adenoma in which there is no response to iodine (reported elsewhere<sup>19</sup>); (2) cases of toxic adenoma complicated by myocarditis, fibrillation, hypertension, diabetes, decompensation, et cetera; (3) cases of

exophthalmic goiter in whom because of pregnancy, previous nerve injury, infections, or other diseases it may be desirable to delay surgery and yet not continue on iodine; (5) cases of iodine-fast exophthalmic goiter; (6) cases of recurrent or persistent hyperthyroidism.

Our experience in all these types of cases with thiouracil has proved encouraging. Probably the gravest risk in the surgical treatment of hyperthyroidism has been brought under control. I refer to the cases of advanced toxic adenoma where a two-stage thyroidectomy has usually been required to safeguard the patient. After preparation for several weeks, I have attempted a one-stage thyroidectomy in several of these patients with satisfactory results.

In two children with exophthalmic goiter the disease has been brought under partial control, but following several weeks' treat-

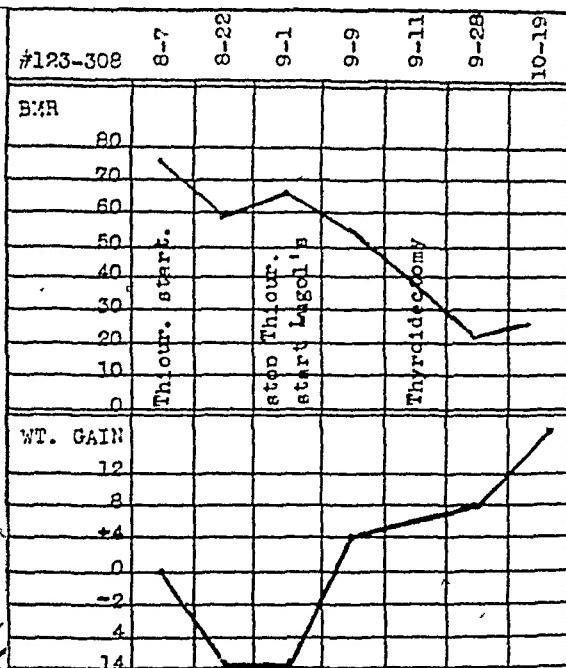
ment there appears to be no indication that a cure will result without surgery.

Three patients with recurrent hyper-

There is an increased sense of well being, the heart beat is slower, and there is less palpitation. There is some gain in weight



A



B

FIG. 7. Case 123-308. A and B, a patient with advanced primary hypothyroidism on whom a primary thyroidectomy was done following the use of thiouracil.

thyroidism have shown a fine response to thiouracil and for the first time are running normal metabolic rates.

In two patients of the iodine-fast type a primary rather than a two-stage operation was done with little reaction.

Dr. Williams<sup>19</sup> advised me that he has successfully treated four women who were pregnant. One was treated for six months preceding pregnancy and throughout her entire nine months of pregnancy. At no time did she have a toxic reaction to the drug, nor did she have any thyrotoxicosis after the first few weeks of treatment.

The clinical improvement in patients that respond favorably is usually noticeable within a few days after starting the drug, but the response is slower in those who have been on iodine. The change is observed by the patients before a drop in the basal metabolic rate occurs. In some cases the gland becomes smaller and firmer, but this is not always true. In most instances the thrills and bruits disappear.

and strength and a decrease in the stare and exophthalmos. Patients complain less of nervousness and insomnia. There is a decrease in the tremor and less sweating. There is less emotional disturbance.

#### PATHOLOGICAL PICTURE

Thiouracil causes an increased vascularity or at least an increased tendency to bleeding, and the glands in primary hyperthyroidism resemble those encountered before Lugol's solution was introduced. The use of the latter combined with thiouracil decreases the bleeding. The typical histological picture of primary hyperthyroidism is markedly altered, but unlike the tendency of hyperplasia reverting to colloid (as seen after Lugol's solution), only little colloid is seen. Occasional infolding areas of epithelium appear, but most of the acini are small and contracted with an increase in the interstitial tissue. The gross appearance of the glands in both

primary and secondary hyperthyroidism does not appear to be changed.

#### SURGICAL RESULTS

Following several weeks preparation with thiouracil, there occurs a marked reduction in the postoperative reaction of both forms of toxic goiter. There has been only slight elevation of the pulse, temperature, and blood pressure and but little nervous reaction in the cases on which I have operated. However, the addition of iodine in the preoperative preparation may also be a factor in the lessened reaction. Thiouracil has been given only for three days after operation, but the patients have been continued on iodine until the postoperative metabolic rates are normal. To date, the recovery of all our patients has been smooth and satisfactory.

#### CASE REPORTS

**CASE I.** (113-573) A female, aged eighteen years, entered the Jackson Clinic on April 1, 1943, with a recurrent exophthalmic goiter and a bilateral adductor laryngeal paralysis. Because of the paralysis, iodine therapy rather than surgery was advised, and the patient's condition was controlled satisfactorily. In December, 1943, thiouracil 0.1 Gm. daily was substituted, and after a week the dosage was doubled. On January 20, 1944, the patient stated that she felt improved. Her heart did not beat so rapidly, and she was less nervous. The pulse rate was 128. Four weeks later she had lost seven pounds, and the basal metabolic rate had gone from +17 to +38 per cent although she felt better, slept better, and was less nervous. She stopped the drug for two months and then was given 0.1 Gm. three times daily. On August 2, 1944, she felt better, the palpitation of the heart had improved, the basal metabolic rate was +21 per cent, and she had gained one and one-half pounds. On September 2, 1944, she had gained three pounds, the basal metabolic rate was +10 per cent, and the pulse rate was 78.

**CASE II.** (122-186) A female, aged thirty years, with a severe case of iodine-fast exophthalmic goiter had been taking iodine for thirteen months before coming to the clinic.

Her basal metabolic rate was +79 per cent, the pulse rate 108.

On June 6, 1944, the patient was given thiouracil 0.1 Gm. twice daily for one week and then three times daily. On June 29, 1944, she reported that she felt much better, less shaky and nervous. On July 10, 1944, she was much improved; her heart was slower, she slept better, there was less tremor, and she was stronger. The presence of a thrill and bruit in the superior thyroid pole was still noted. The patient had gained seven pounds and was continued on the above treatment. On July 24, 1944, she returned, reporting a gain of eight and one-half pounds in two weeks. The basal metabolic rate had dropped to +56 per cent. She felt generally improved. The thrill and bruit had gone. The thiouracil was increased to 0.3 Gm. and 5 drops of Lugol's solution was added. On August 14, 1944, the basal metabolic rate was +49 per cent, and thiouracil 0.4 Gm. was given. Two days later a primary thyroidectomy was done. There was very little reaction. On September 7, 1944, the basal metabolic rate was +2 per cent. She had gained fifteen pounds and felt very well.

**CASE III.** A female, aged sixty-five years, whose case was diagnosed as a subtotal toxic adenoma of the thyroid had lost twenty pounds in the previous three months, was very feeble, and had marked tremor and dyspnea. The basal metabolic rate was +87 per cent, the pulse rate 108 and the weight 108 pounds. The blood pressure was 178 mm. systolic and 80 mm. diastolic. The quadriceps loss test was positive 3, on a scale of 1 to 4. She was considered a rather poor surgical risk.

On June 26, 1944, the patient was hospitalized and put on thiouracil 0.1 Gm. three times daily. On July 1, 1944, the basal metabolic rate was +59 per cent, the pulse rate 90 and the weight 106 pounds. Generally, the patient felt much improved and appeared to be considerably stronger. It was decided that a primary thyroidectomy could be done, and it was performed on July 5, 1944. The patient made an uneventful recovery, and the postoperative reaction appeared to be less severe than one would expect in such a case.

Two months later she reported she had gained sixteen pounds and was feeling fine. Her basal metabolic rate was +41 per cent; the pulse rate was 84. She was given thiouracil 0.4 Gm. daily. She followed this treatment for

two and one-half weeks but discontinued it for a few days because of looseness of stools. On October 21, 1944, the basal metabolic rate was +19 and the pulse rate 72. Thiouracil 0.3 Gm. daily was continued.

CASE IV. (106-331) On June 19, 1940, I performed a thyroidectomy for exophthalmic goiter on a male, aged twenty-nine years. The patient made a good recovery. On October 26, 1940, he had mild symptoms of hypothyroidism. His basal metabolic rate was -22 per cent, his weight 142 pounds, and his pulse rate 55. He then assumed a strenuous war job in Detroit for three years.

On May 13, 1944, he returned with a recurrence of his goiter. The basal metabolic rate was +88 per cent, the pulse rate 90 and his weight 124 pounds. He was smoking one package of cigarettes a day, drinking coffee, and otherwise disregarding instructions. He was placed on Lugol's solution, 5 drops three times daily. On June 19, 1944, his basal metabolic rate was +55 per cent, his pulse rate 84 and his weight 133 pounds. He seemed generally improved and stated that he felt fine. At this time Lugol's solution was stopped and he was given thiouracil 0.1 Gm. daily. On July 10, 1944, he stated that he felt much better although he had lost five pounds in weight. The basal metabolic rate had gone up to +59 per cent; the pulse rate was 95. Thiouracil was then increased to 0.1 Gm. three times daily. On August 3, 1944, the basal metabolic rate was +72 per cent. He stated that he was feeling fine and had gained one and one-half pounds. Thiouracil was increased to 0.4 Gm. daily. Three weeks later the basal metabolic rate had dropped to +42 per cent, and he had gained six pounds. On November 2, 1944, he reported that he was feeling fine. His basal metabolic rate was -12 per cent, the pulse rate 61 and his weight 143½ pounds.

CASE V. (121-884) A female, aged eighteen years, whose condition was diagnosed as a severe case of iodine-fast exophthalmic goiter had been taking Lugol's solution for two and one-half years before coming to the clinic. The basal metabolic rate was +72 per cent, the pulse rate 120 and the weight 146 pounds. She had a grade 4 enlargement of the gland and was considered to be a poor surgical risk. The blood pressure was 160 mm. systolic and 80 mm. diastolic. She was extremely toxic.

The patient was placed on thiouracil 0.1 Gm. twice daily. On June 13, 1944, this was increased to three times daily. At this time the basal metabolic rate had dropped to +45 per cent, the pulse rate was 108 and the weight was 143 pounds. On June 23, 1944, thiouracil was decreased to twice daily and the use of Lugol's was discontinued.

On July 5, 1944, the basal metabolic rate went up to +71 per cent, but she had gained 4 pounds in weight. She complained that her heart was very rapid and pounding and that she did not feel as well as when taking Lugol's. It was decided to resume the iodine but to continue on thiouracil 0.1 Gm. twice daily. The patient was hospitalized, and her blood pressure decreased to 138 mm. systolic and 75 mm. diastolic. During the next week the patient showed marked improvement. The basal metabolic rate dropped to +39 per cent. Although she again lost weight, the pulse rate remained at 116.

At this time it seemed advisable to do a first-stage thyroidectomy, and a sub-total resection of the right lobe and isthmus was performed. The gland proved to be extremely vascular and friable. There was very little postoperative reaction. The patient was out of bed on the third day.

Five weeks later a left lobectomy was performed with a moderate reaction. Seven weeks later she had gained sixteen pounds, but the basal metabolic rate was still +34 per cent and the pulse rate 108, so she was continued on Lugol's solution 5 drops three times daily. Clinically she appears well, but it may be advisable to drive this rate to normal with thiouracil.

CASE VI. A female, aged thirty-six years, came to the clinic on November 12, 1943, with a recurrence of exophthalmic goiter. Thyroidectomy had been performed elsewhere in 1931. The basal metabolic rate was +54 per cent, the pulse rate 112.

On November 24, 1943, I performed a sub-total resection of the three lobes of the thyroid leaving only the usual fractional amount. Recovery was uneventful, but the basal metabolic rate never returned to normal, nor could the patient be considered entirely well. In five months she gained twenty pounds, but the basal metabolic rate was +29 per cent. She was continued on Lugol's solution for nine months, but because of influenza and

overwork she did not fully recover. On June 16, 1944, she was given thiouracil 0.1 Gm. plus 5 drops of Lugol's solution. Ten days later she had lost four pounds but felt better. Thiouracil was increased to 0.2 Gm. daily and Lugol's solution was stopped. The basal metabolic rate rose to +39 per cent by August 3, 1944, but three weeks later dropped to +11 per cent, and she felt much better. Thiouracil was increased to 0.4 Gm., and on September 7, 1944; the basal metabolic rate had dropped to +5 per cent, and she had gained eleven and one-half pounds. By October 6, 1944, she had gained another five pounds and was on a maintenance dose of 0.1 Gm. of thiouracil. To date this patient has shown the most satisfactory response to the drug.

**CASE VII.** A female, aged fifty-two, was admitted October 13, 1944, with a diagnosis of multiple toxic adenoma and rather severe diabetes. The basal metabolic rate was +40 per cent. The patient had lost fourteen pounds in the two weeks prior to admission. This type of case, complicated by severe diabetes, is one in which thiouracil may greatly lower the risk of surgery and safely permit a one-stage operation. The patient was given thiouracil 0.4 Gm. daily and prepared by diet and insulin. A thyroidectomy was performed October 20, 1944, with but little reaction. The patient has made a very satisfactory recovery.

**CASE VIII.** A female, aged forty-one, was admitted September 21, 1944, with a diagnosis of multiple toxic adenoma with secondary hypertension and chronic myocarditis. The basal metabolic rate was +66 per cent. Thiouracil 0.6 Gm. was given daily for ten days, and then 5 drops of Lugol's solution was added for five days. On October 3, 1944, the basal metabolic rate was +57 per cent, and although she had gained only two pounds, she felt considerably improved, was less nervous, and felt stronger. On October 11, 1944, a primary thyroidectomy was done; there was but slight reaction, and the recovery has been excellent.

**CASE IX.** (124-564) A female, aged twelve, was referred by her physician, Dr. R. Roberts, with a diagnosis of exophthalmic goiter. Typical history and physical findings confirmed the diagnosis. The child was twenty-three pounds underweight. The basal metabolic rate was +31 per cent on October 6, 1944.

She was hospitalized for a week on thiouracil 0.3 Gm. daily. She showed improvement, was less nervous, and slept better. Her heart was quieter, and on October 10, 1944, her basal metabolic rate had dropped to +20 per cent. She was sent home on the above dosage and returned November 1, 1944. Her basal metabolic rate was now +38 per cent (up 18 points). Her pulse was up 11 points, but she had gained four pounds. She is to continue on thiouracil 0.3 Gm. daily. Either the dosage is too small, or the drug is not effective in this child.

**CASE X.** (123-459) A female, aged twenty, was admitted on August 16, 1944, with a severe case of partly iodine-fast exophthalmic goiter. She had received the drug for four weeks prior to admission when the basal metabolic rate was +41 per cent. She was given thiouracil 0.4 Gm daily, and on August 30, 1944, the basal metabolic rate was +28 per cent. But on September 23, 1944, the basal metabolic rate had gone up 15 points. There was no improvement, and the exophthalmus had increased. In addition to the thiouracil 10 drops of Lugol's solution was given three times daily. On September 23, 1944, the basal metabolic rate was down to +16 per cent, and a primary thyroidectomy was done with but little reaction. This case represents the delayed action of thiouracil due to iodine.

#### CONCLUSIONS

A report of thirty cases of hyperthyroidism treated with thiouracil is presented.

Sufficient time has not elapsed, and a sufficient number of cases has not been studied to warrant any definite conclusions about the permanent efficacy of this drug.

In view of the numerous complications arising from its use (including seven fatal cases of agranulocytosis in a series of approximately 2,000 cases) every safeguard should be used to protect the patient receiving the drug.

Because of the fact that approximately 83 per cent of the patients receiving thiouracil are benefited, its further investigation appears justified.

Six special indications for which the drug seems indicated are listed.

From a study of this small series of cases, it does not appear that thiouracil will supplant surgery in the treatment of exophthalmic goiter. In toxic adenoma it will not exclude thyroidectomy, but it may eliminate a two-stage operation.

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# SURGICAL TREATMENT OF CANCER OF THE COLON AND RECTUM\*

CHAS. GORDON HEYD, M.D.

Professor of Surgery, New York Post-Graduate Medical School, Columbia University  
NEW YORK, NEW YORK

FOR some reason the expression, "cancer of the rectum," is associated with a greater psychological reaction upon the part of the patient than is the diagnosis of cancer of the stomach. It is difficult to explain this reaction for the ultimate prognosis for a patient operated upon for carcinoma of the rectum is at the present time far superior to the prognosis that obtains after resection of the stomach for carcinoma. Perhaps the inevitable and visible colostomy with permanent loss of normal rectal evacuation is largely responsible for this state of mind.

It is a commonplace observation that innumerable patients suffer varying degrees of bowel discomfort with rectal bleeding rather than go to a doctor for surgical relief. Probably in no field of abdominal surgery has such rapid and satisfactory advances been made in diagnosis, operability, operative technic and ultimate cure as in neoplasms of the large bowel. There are certain general characteristics that apply to neoplasms of the large bowel, and it is upon these characteristics, both technically and anatomically, that there is such a wide choice of technical procedures. For reasons of clarity neoplasms of the large bowel including the rectum may be allocated to: (1) neoplasms that involve the cecum and the right side of the colon, (2) neoplasms that involve the left colon, from the midpoint of the transverse colon to the rectosigmoid, and (3) neoplasms involving the rectosigmoid and anus. One might employ a phrase, "a shift to the left," to indicate that with localization of a neoplasm from the cecum upward to the left and downward, there is a marked change in the surgical char-

acteristics of the neoplasm. There is an increase in the intrinsic virulence of the cancer cell, an increased tendency for glandular metastases, an increase in the obstructive element of the tumor, and finally a radical change in the technical procedures for extirpation.

Neoplasms of the right colon tend to be broad, flat, ulcerous tumors, remaining local for an indefinite period, with a low biotic virulence, and with metastases relatively late. Owing to the large lumen of the cecum and ascending colon, together with the small amount of fibrous tissue elements in the neoplasm, there is very little tendency toward obstruction. This general picture is in contrast with a neoplasm of the sigmoid where the tendency to ulceration is less than on the right side, where there is a large amount of fibrous tissue elements in the neoplasm with the production of varied and varying degrees of obstruction, and where the cancer cell is more virulent and tends to metastasize more quickly into the lymph glands of the area.

The symptomatology also varies with the location of the tumor but there are three symptoms, either separately or combined, which are almost invariably present with all types and locations of neoplasms: (1) the presence of blood, either occult or frank; (2) pain, and (3) disturbance in bowel rhythm. With right-sided neoplasms, with their flat surface and large ulceration there is a continuous and progressive anemia. This anemia is a severe type of secondary anemia, and is the result of many factors: (1) The progressive character of the malignant ulceration causes a continuous loss of blood in varying

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amounts; (2) the absorption of cancer detritus, plus partially digested blood, acts as a hemolytic agent. A suspicion of cancer

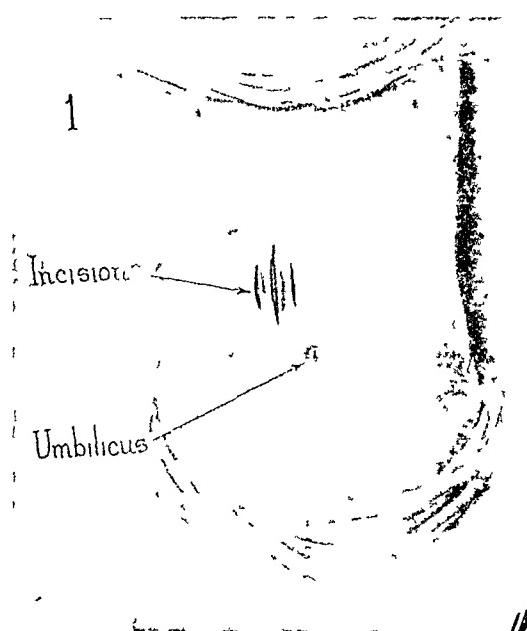


FIG. 1. Indicates the three incisions made in the right upper quadrant, far removed from the area of the cancer

of the right colon may be entertained when a mature individual shows a pronounced anemia. This anemia sometimes is comparable to the clinical appearance of pernicious anemia. In general, only three other conditions must be excluded: carcinoma of the stomach, chronic nephritis and pernicious anemia. With a shift to the left in the localization of the tumor the obstructive and pain symptoms predominate and the anemia is not so apparent or noteworthy. It is not an infrequent occurrence for a surgeon to find a neoplasm of the sigmoid during the course of a laparotomy for a totally unrelated surgical condition such as an hysterectomy or cholecystectomy. A cancer of the cecum or ascending colon rarely causes in the early stages any marked interference with bowel function. With a cancer of the left and distal colon there is a tendency for some interference with bowel function and in many cases there is an intermittent constipation. The patient will volunteer the information that the cathartic pills that

he has been in the habit of taking fail to move his bowels or if they do the movements are associated with a greater degree of cramps. It is rather interesting that about 10 per cent of people with a cecal carcinoma discover a lump in the right side before consulting a physician, and about 5 per cent of sigmoidal tumors enter the hospital with a complete intestinal obstruction as their first declarative symptom. Of outstanding significance in carcinoma of the rectosigmoid and rectum is the history of many, rather futile bowel movements, not in the nature of a diarrhea but urgent calls to the toilet to expel a quantity of gas and mucus mixed with blood. The patient will declare that he does not have a diarrhea but if you put the question: How many times do you go to the toilet to pass a small amount of feces with mucus and blood? the reply will be, "many times." Further evidence of this rectal urgency will be found in the fact that many of these patients have fecal stains on their underwear or wear a diaper or pad in their drawers to guard against "accidents." It is also worthy of note that about 20 per cent of people with carcinoma of the rectum have been either operated upon or treated for hemorrhoids.

If and when a patient observes blood, either incorporated with the stools or as frank blood in the bowl of the toilet, or on the toilet paper, it calls for a very definite determination of the source of the bleeding. Blood from hemorrhoids can usually be quickly determined by a proctoscopic examination and the visualization of normal colored stools above the proctoscope or in causing fresh bleeding from the manipulation of the instrument. Occasionally, a frank rectal hemorrhage may present a diagnostic problem of great magnitude. In December, 1941, a physician, fifty years of age, enjoying excellent health, one evening after dinner was seized with rather intense abdominal cramps. He went to the toilet and had a normal bowel movement and then within forty-eight hours began to have bloody stools, with a

fall in his erythrocytes to slightly over 2,000,000, and a hemoglobin of 40 per cent. X-ray studies of known competency could

again examined six months later and "notwithstanding the use of the double contrast method as well as compression, a definite

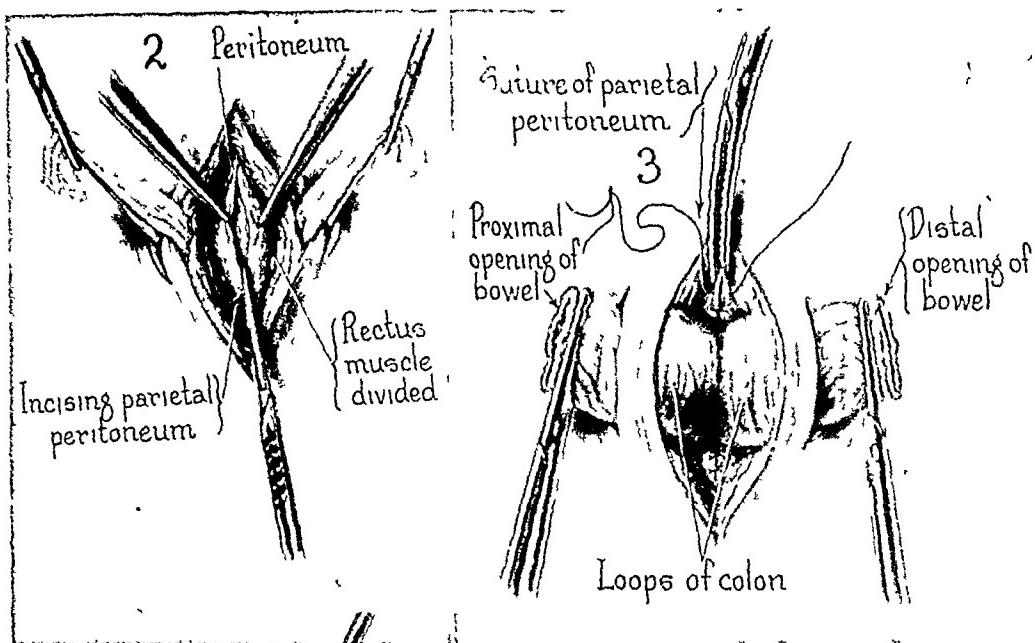


FIG. 2. The mechanism of preparation of the lateral orifices for the Devine colostomy.

FIG. 3. The divergent loops of the Devine colostomy after being brought through the lateral incisions.

find no cause for the hemorrhage and proctoscopic examination was negative. The patient made a slow recovery back to a normal blood picture and a rather dubious diagnosis was made of intestinal varix. The patient has had no other attack of bleeding and has remained well. In contrast, a female, fifty years of age, consulted me in December, 1939, with the history of "passing blood by rectum for the past nine months." A diagnostic study was undertaken by her physician, Dr. A. A. Jaffe, of Jersey City, and a diagnosis of "polyp of the descending colon" was made. A sigmoidoscopic examination at this time was negative upon the introduction of the instrument to the extent of ten inches. The stools suggested a continuous seepage of blood rather than any frank hemorrhage. A second barium colon enema, about one month later, revealed moderate irritability of the colon, and probably a small isolated polyp of the sigmoid. For two to three weeks at a time the stools would be free of blood. The patient was

interpretation of polyposis is not justifiable." The patient gained weight and apparently the bleeding by rectum diminished. However, in February, 1941, Dr. Jaffe was positive that there were two discrete polypi in the sigmoid. In view of all the negative x-ray examinations of the stomach, gallbladder, etc., it was assumed that these polypi were the cause of her hemorrhage. After a convass of the situation, on March 5, 1941, an exploratory sigmoidotomy was performed and two polypi were found, one approximately 3 cm. in length, and the other 2 cm. in length, and both located within 10 cm. of each other. Both polypi were excised, and the bases cauterized followed by a sigmoidorrhaphy with complete relief and cessation of bleeding.

In no other surgical condition of the large bowel is there so great an inherent tendency for a primary non-malignant lesion of the colon to become malignant as in polyposis. There is a strong family disposition to polyposis and numerous

histological examinations of polypi removed at operation have showed independent cancer degeneration simultaneously

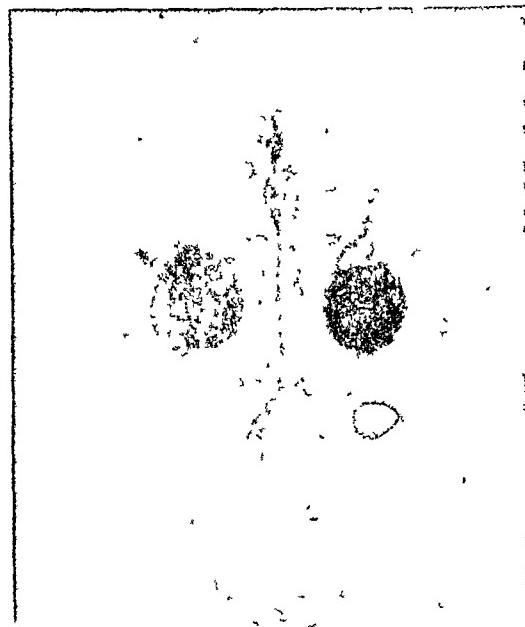


FIG. 4 The appearance of a Devine colostomy four days after operation. Note the wire suture and small piece of gauze at lower angle.

in two or more polypi. The predisposition to cancer is well illustrated in the observations of Rankin which strongly emphasize the familial disposition to polypi and high incidence of malignant degeneration.

Occasionally, a polyp is detected in the upper rectum and there is a temptation to attempt its excision through the proctoscope in the doctor's office. This should be deprecated as the office facilities are many times not complete, and a hemorrhage following the excision in the office may be quite alarming and with the patient not anesthetized attempts at packing will be painful, incomplete and often nugatory. It is much safer to have the patient in the hospital and anesthetized.

The colon that is the site of a malignancy is one which has lost considerable of its normal tissue resistance as well as its reparative and recuperative power after operation. In a lesion so situated as to produce some element of obstruction, slight though it may be, there is a simul-

taneous hypertrophy of the bowel proximal to the lesion, with increasing distention and with retention or stasis of colonic contents. This proximal loop of bowel is essentially a living test tube teeming with highly virulent organisms. It is a bowel that does not lend itself to resection and particularly to primary end-to-end anastomosis. Leakage after an end-to-end anastomosis for an obstructive malignancy occurs not so much from the giving way of the suture line, *per se*, as leakage through the stitch holes, for a bowel proximal to an obstruction is to a large extent one that is lacking in viability and will frequently leak with a resulting peritonitis.

Certain broad surgical principles are inherent in any technical procedure for resection of a malignant tumor of the colon or rectum. They may be listed seriatim: (1) It is imperative to relieve all proximal bowel distention. The ordinary medical measures for decompression of the bowel are in the majority of cases quite satisfactory. Irrigations, salines by mouth, non-residue diet, rest in bed, application of external heat to the abdomen, will in many cases suffice. If, however, the giving of a saline cathartic is associated with an increase in abdominal pain, the patient should have an operative decompression before resection is attempted. (2) To restore the patient's general condition to as near the age norm as possible, the measure adopted consists of high caloric, high protein diet, forced fluid intake, preferably giving at least one intravenous infusion of normal saline plus 5 per cent dextrose daily. If a second infusion per day is given, I usually prefer 1,000 cc. distilled water plus 5 per cent dextrose. (3) Blood transfusions are of marvellous assistance in reconditioning the patient for surgery. The number and frequency will depend upon the clinical findings and certainly one transfusion of 500 cc. should be given during or immediately after the resection. A determination of serum protein before and after operation is a very valuable aid in estimating the degree and

possibility of a pre- and postoperative hypoproteinemia. (4) An adequate survey of the cardiorenal system. In short, the

nificant contributions to colon surgery. It is performed through a right upper quadrant incision and on that portion of

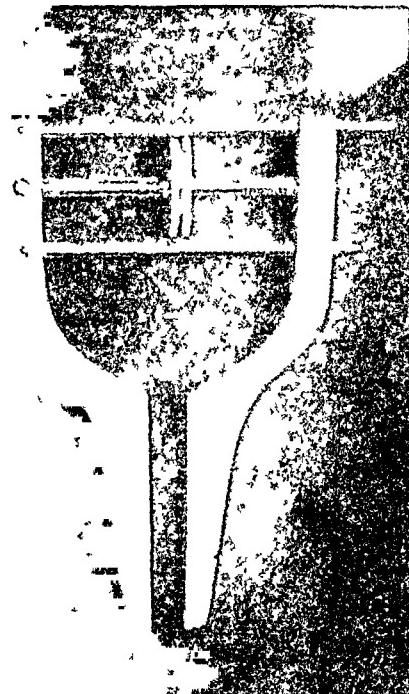
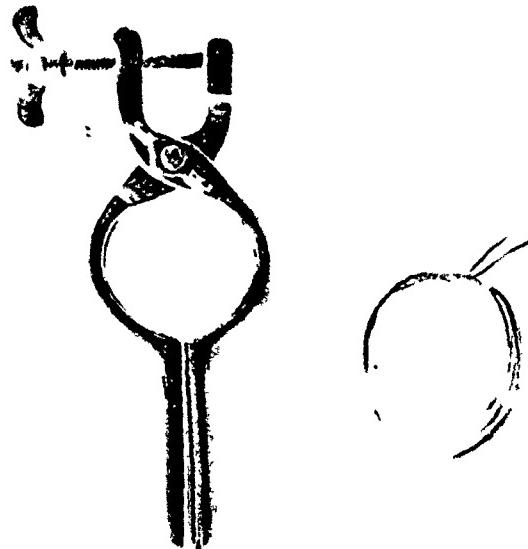


FIG. 5. At left the Devine spur clamp; in the middle, a sample of Malin stainless steel wire; at the right the Ochsner-deBakey-Devine spur clamp

utilization of any and all measures to make the patient safe for surgery. The surgeon alone can determine what surgical technic, either singly or in stages, will be safe for the patient. (5) The preoperative and postoperative use of sulfa drugs and plasma.

Cecostomy is seldom a satisfactory method to accomplish decompression. At the best it will relieve only the gaseous distention proximal to the obstruction but it will not completely deflect the fecal current. It does not diminish the virulence of the intestinal contents and technically it does not function well in fully half the cases in which it is performed.

We are convinced that practically all tumors on the left side of the colon can be rendered safe for any technical procedure, with a low mortality, and a rapid convalescence if the Devine colostomy is employed. The Devine colostomy, as a preliminary operation for a resection of the colon or the anus, is one of the most sig-

the transverse colon between the hepatic flexure and the mid-point of the transverse colon. It allows complete intra-abdominal exploration, and is easily performed. The patient can take care of it with a minimum degree of trouble.

An incision approximately 7 to 10 cm. in length is made about 3 cm. from the mid-line in the right upper quadrant and about halfway between the ensiform and the navel. The peritoneal cavity is opened and the gloved hand smeared with sterile vaseline is introduced and an abdominal exploration carried out. Exact information is acquired as to the location of the growth, the associated bowel inflammation, the occurrence of metastatic glandular invasion, the condition of the cul-de-sac of Douglas, the presence or absence of metastases in the liver, and the general condition of the large bowel proximal to the obstruction. The right half of the transverse colon is mobilized and delivered through the incision. A tape is passed

beneath the bowel and the gastrocolic omentum and the great omentum are dissected free so as to permit the approximation of the two ends of the transverse colon which have been divided between the clamps with the cautery. The free loops of the right and left portions of the transverse colon are

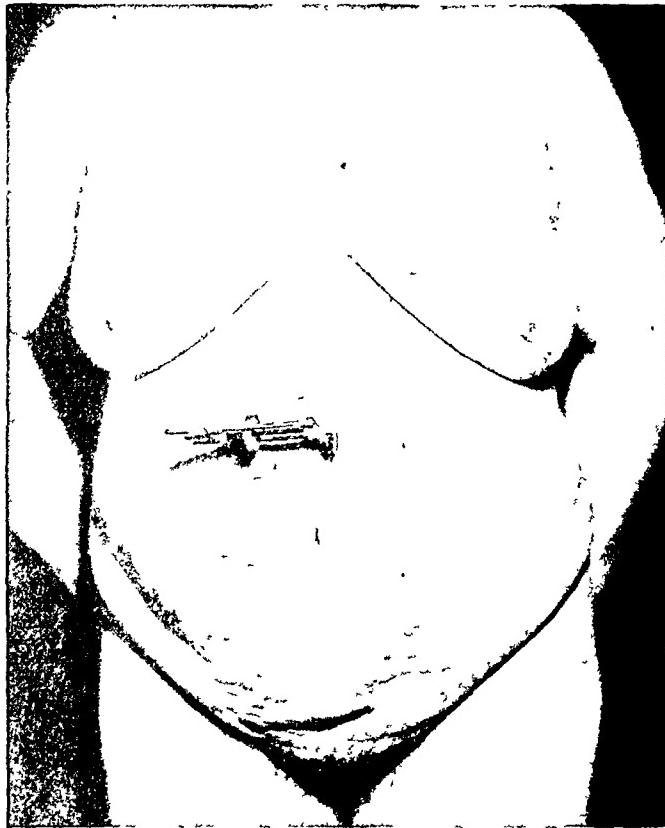


FIG. 6. The reconstruction of colonic continuity with the special spur clamp; patient up and about the ward.

mation of the inferior white band on both loops for a distance not less than 12 cm. and up to a point about two inches below the tape. In this manner the "double-barrel" portion of the colon suspended on the tape comes through the abdominal incision freely and easily. On each side at approximately the middle point of the abdominal incision, but about 3 cm. to the right and left of the incision, a stab wound through skin and subcutaneous fat is made no longer than 2 or 3 cm. The colon loop is held in the mid-portion of the original incision and the peritoneal cavity closed rather snugly about it but no sutures are placed into the bowel wall. Two crushing clamps are then introduced, one from each side, through the stab wounds and placed close together on the bowel. The gut is then

then brought out respectively through the right and left lateral stab wounds and held in place without suture by the occlusion clamp. The abdominal wound is then closed with michel clips and a short latex drain is inserted in the lower angle. It is of great importance that the skin of the stab wound fit very snugly around the bowel without sutures as the desired end result is that the colostomy orifices of both bowel ends when finally healed shall have a diameter not greater than  $1\frac{1}{2}$  cm. When the proximal colostomy orifice is small, free exit is provided for the soft contents of the ascending colon and cecum, yet there will be sufficient impediment to uncontrolled discharge as to permit most of the fluid being retained by the patient. No fear need be entertained of any ob-

structive symptoms as the soft contents of the cecum and ascending colon will be readily evacuated.

The following advantages are obtained with this technic: (1) An absolute and complete separation of the fecal current from the proximal to distal loops; (2) complete decompression of the obstructed loop; (3) the ability to render less septic the obstructed loop by bowel irrigations of mild antiseptics and the introduction of aqueous solutions of the sulfa drugs. In the course of two or three weeks an obstructed loop will have resumed its normal tone, the inflammatory changes in and about the tumor will have subsided, the tumor itself will have shrunk, and the contents of the bowel will be of a low attenuated virulence. (4) The patient will have one, at most not more than two, bowel movements a day from the colostomy. The stool will be of a soft homogenous consistency and readily controlled without any bag or container. A Trask colostomy "hat" will provide a safe firm dressing and control. (5) The re-establishment of bowel continuity is readily performed later, after the resection by the special Devine spur crushing clamp. This stage requires only from three to four days in the hospital. If leakage occurs at the site of the resection of the neoplasm, it can be allowed to heal by granulation without any further surgery as the present of the Devine colostomy prevents any contamination about the area of the resection with stool. (6) The closure of the abdominal orifices of the Devine colostomy does not require any further surgery. By cauterization of the mucous membrane with the actual cautery the orifices gradually close in by themselves.

By utilizing the preliminary Devine colostomy procedure it is possible after three or four weeks to resect any tumor on the left side even into the upper portion of the rectum, and to perform an end-to-end anastomosis with the reasonable expectation that the bowel union will heal per primam, and without leakage. The

greatest value, however, of the Devine colostomy is in a patient in whom the tumor on abdominal exploration made at the time of the colostomy seemed to be inoperable, but which in the course of three or four weeks after the colostomy when freed of the continuous irritation and contamination of the stool shows almost complete resolution of the surrounding inflammation and to have become capable of resection. If any one feature of the Devine colostomy warranted its place in the technical resources of the surgeon, it is the increased ability to resect tumors of the left colon that on first palpation seemed beyond surgical resection. Furthermore, so significant is the resolution of the inflammation surrounding a low rectosigmoidal growth, together with the shrinking of the tumor and its increased mobility four weeks after a Devine colostomy, that it is possible to do a low rectosigmoid resection instead of an abdominal perineal resection.

I am prepared in view of my experience with the Devine colostomy to go even further and state that it is in my opinion the best mechanism for treating perforating diverticulitis. Assuming that most cases of perforating diverticulitis will, if competently watched, resolve and recover without surgical intervention, there are still some cases which will perforate and if the diverticulitis is attacked directly the result can only be an incomplete operation of drainage, or a formidable operation of resection, with a low colostomy and a high operative mortality. A preliminary Devine colostomy is readily tolerated by the patient, assures complete intestinal rest to the sigmoid, and will permit at a later date if necessary an operation without a prohibitive mortality.

#### CASE REPORT

A male, age sixty-three, entered a hospital in a nearby town, with a complete intestinal obstruction due to a rectal mass diagnosed as inoperable carcinoma of the rectum. A colostomy was recommended, together with x-ray

therapy. The patient was brought to New York and entered the Post-Graduate Hospital. The rectal obstruction was so complete that a barium colon enema could not be introduced. The patient's history was characterized by three significant features: (1) intermittent pain in the left lower quadrant, (2) bladder irritability with painful micturition and (3) an absence of blood in the stools. On examination the patient had a mass in the left lower quadrant. On rectal examination there was complete obstruction from a large, tender pelvic mass. There was no rectal bleeding upon examination. A preoperative diagnosis of perforating diverticulitis of the sigmoid was made.

The operation consisted of a Devine colostomy through the right upper rectus muscle. On opening the abdomen a complete exploration was carried out, with the following findings: The descending colon passed down unimpeded into the sigmoid where an infiltrating process involved the entire wall of the bowel and extended from the sigmoid to the junction of the rectum proper. There was a marked inflammatory reaction surrounding the mass so that it was fixed to the lateral and posterior wall of the true pelvis. The small intestines seemed to be normal. The liver was without any palpable or visible evidence of metastases.

The patient left the hospital fifteen days after the Devine colostomy was performed. Two months later a barium colon enema from below upward to the left upper colostomy opening did not show any x-ray evidence of obstruction. The beginning of the sigmoid for a distance of 8 cm. showed irregularity and small pocket-like diverticula. X-ray examination from above downward through the left upper colostomy opening did not show the presence of any obstruction. Three and a half months from the time of the Devine colostomy an Ochsner-De Bakey spur clamp was applied and bowel continuity re-established. One month later the right colostomy wound closed spontaneously and a few weeks later the left colostomy opening was closed after two cauterizations of the mucous membrane and granulation tissue.

This case illustrates the application of the Devine colostomy for the relief of intestinal (colon) obstruction. A further advantage is based upon the fact that the

fecal contents of the right colon are completely "side-tracked" from the left colon and at the same time preparations were made for any subsequent surgery that might become necessary. It is the underlying philosophy of the Devine colostomy that seems to me most important. At the present time, it is the only procedure performed remotely from the field of pathology that can give much manifest benefits and simultaneously prepare the patient for a successful approach to the initial lesion at a later time with a low mortality.

I would like to bring to your attention the use of stainless steel wire for closure of the abdominal wall after colon surgery. Its usefulness was demonstrated by Dr. Tom Jones at the Crile Clinic in the closure of the abdominal wound after an abdominoperineal resection. The abdominal parieties are closed by through-and-through interrupted sutures of Malin stainless steel wire. The wire ties almost as readily as linen, and is usually well tolerated by the tissues. It promotes a firm abdominal closure without infection. The presence of catgut or linen in an abdominal wound, through which a resection has been performed, is many times infected regardless of the technic employed, and the peritonitis that occurs a week after a resection is often times due to a breaking into the peritoneal cavity of an infectious process of the abdominal wall. Since we began to use steel wire our wound infections have been remarkably reduced. At the present time, I personally employ the Devine colostomy as a preliminary measure before an abdominoperineal resection of the rectum for carcinoma. The colostomy is far removed from the operative field. After two weeks, the bowel function through the Devine colostomy will be regular and normal. The left colon and rectum will be rendered as nearly aseptic as possible by the treatment outlined above. The inflammatory changes incident to the tumor will have subsided and the abdominoperineal resection can be more easily performed with less mortality than

usually attends this severe operation. To do a two-stage abdominoperineal resection and have the permanent end colostomy in or about your operative wound at the second stage is not only prejudicial to its sterility, but in addition the adhesions that one sometimes encounters nullifies at the second operation the effectiveness of the two-stage procedure in that at the second stage so much time has to be consumed in separating the adhesions of the previous operation. With a previous Devine colostomy none of these hazards or embarrassments are present.

There is another benefit in employing a Devine colostomy as a preliminary to an abdominoperineal resection and that is the improvement of the patient's morale after the colostomy. The rectal tenesmus is terminated. The appetite improves. The pain largely disappears and the patient's sense of well being is remarkably enhanced. Psychologically he approaches the second operation with a much better frame of mind. The improvement has largely conquered his fear and anxiety.

In a resection of the cecum or ascending colon, it is our practice to blind the terminal ileum and the proximal end of the transverse colon and do a typical lateral anastomosis. Somewhat proximal to the anastomotic opening a stab wound is made in the large bowel and a female pattern self-retaining catheter inserted, using the technic of Witzel as applied in a Witzel gastrostomy. The catheter stem is brought out through the separate stab wound and very effectively maintains decompression of the large bowel. If and when the purpose of the catheter colostomy has been fulfilled, the stem of the catheter is pulled somewhat taut and then cut off close to the skin. In the course of a few days or a week the ballooned tip of the catheter will be passed by rectum. This little procedure

allows the removal of the tube without the trauma that must ensue if it is dragged out of the bowel through the abdominal wall.

The increasing usefulness of the Devine colostomy may also be emphasized by the fact that it offers by all odds the best permanent colostomy. If the functional utility of the colostomy is to be gauged by the criteria I have indicated, the Devine colostomy meets all these conditions. An additional indication for its employment would be in the treatment of the anorectal syndrome of lymphogranuloma venereum.

Up to date the Devine colostomy has been utilized in thirty personal cases. There were no mortalities following this technic. The indications were partitioned as follows:

1. As a preliminary to abdominal perineal resection	10
2. As a preliminary to resection of the rectosigmoid	4
3. As a preliminary to resection of the sigmoid	5
4. As a preliminary for the treatment of diverticular tumor	4
5. As a permanent colostomy for ulcerative colitis	4
6. As a temporary procedure for anastomotic leakage after resection of the left colon	1
7. As a temporary procedure in sigmoidal vesical fistula	1
8. As a permanent colostomy in destruction of the rectum due to lymphogranuloma venereum	1
Total	30

#### CONCLUSIONS

1. The Devine colostomy extends the indications and resectability for cancer of the left colon, rectosigmoid and rectum.
2. It is the most efficient temporary or permanent colostomy.
3. It is technically easy to perform.
4. It is without mortality *per se*.
5. Colon continuity may be re-established at any time by a simple procedure with a special clamp.
6. It is a fundamental contribution to surgery of the colon.



# IMPROVED BREAST LIFTING OPERATION

A. GRAHAM BIDDLE, M.D.

NEW YORK, NEW YORK

THE surgical correction of pendulous breasts has received comparatively little attention by the general surgeon. Aside from breast amputation for cancer, an operation for reduction in size and restoration to the normal position has been avoided. Even those who specialize in plastic surgery, who employ a great variety of methods, evidence a need for a standard procedure by which successful results may be reasonably assured. My attention was first directed to this type of surgery after I had witnessed the result of operations by various corrective measures as employed by other surgeons, and came to the conclusion that there was plenty of room for improvement. The improved method which I now use, and have used successfully in a number of cases, appears to have each step following the previous one in logical sequence, and the instruments which I have devised enables one to perform the operation quickly and without guesswork, and the results more nearly approach the normal, in that successful functional and cosmetic results are more certain of attainment.

It is not necessary to go into detail as to why a woman having enlarged and pendulous breasts desires to have these reduced in size and restored to their normal position on the chest wall. I shall simply try to describe the details of the operation as modified by me and the how and why the instruments which were devised by me can be used to produce a result which will please the patient as well as the surgeon performing the operation.

Measurements taken of the position of thousands of normal breasts show that the average position of the nipples is four and one-half inches from the midline, and opposite the third and four costal interspace. The nipples are nine inches apart,

one at each angle of the base of a triangle with the apex at the suprACLAVICULAR notch. With these measurements in mind, I had a triangle constructed of German silver, with a sort of button embedded in the apex, the undersurface projecting a slight distance. When this is placed in the sternal notch and allowed to rest on the chest, it will be found that each nipple is seven to eight inches from the apex of the triangle, and nine inches apart. Use is made of this triangle prior to the operation to indicate approximately where the nipples should be, and during the operation while suturing to make one confident that the nipples have been relocated correctly. (Fig. 5.) When performing the operation, it is entirely unnecessary to make elaborate measurements showing where the nipple should be located, as described by previous authors. The triangle which I have devised does this quite accurately, and eliminates the possibility of a mistake. Some articles describe a method in which a buttonhole incision is made at the time of the operation so placed that when the breast is placed in position it will protrude through this button hole. The operation as now performed eliminates this step completely.

The primary incision is usually made by the majority of operators underneath the breast, running horizontally in a curvilinear fashion extending the full length of the breast even out into the axillae. This method of operating has been abandoned because the ends of the incision may be visible when wearing an evening gown or a slim bathing suit. The cut as now made extends only from the nipple to the chest wall in a vertical direction. Thus the scar will be hidden by the bathing suit and evening gown, and the incision gives the surgeon more freedom of approach

than when placed in any other position. (Fig. 10.)

It is my custom when preparing these

are healing. Nembutal gr.  $1\frac{1}{2}$  may be prescribed for a pleasant sleep in the case of apprehensive patients. About one hour

FIG. 1.

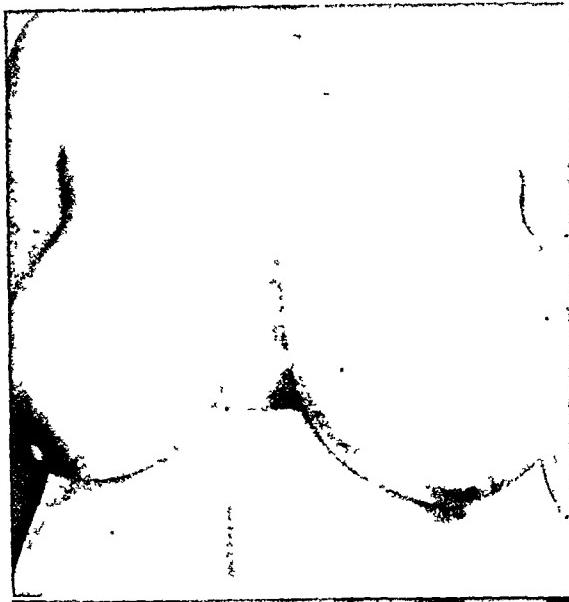


FIG. 2.

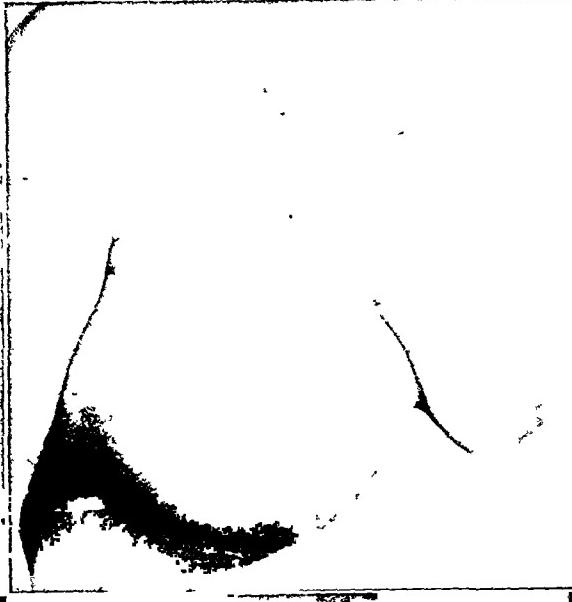


FIG. 3.

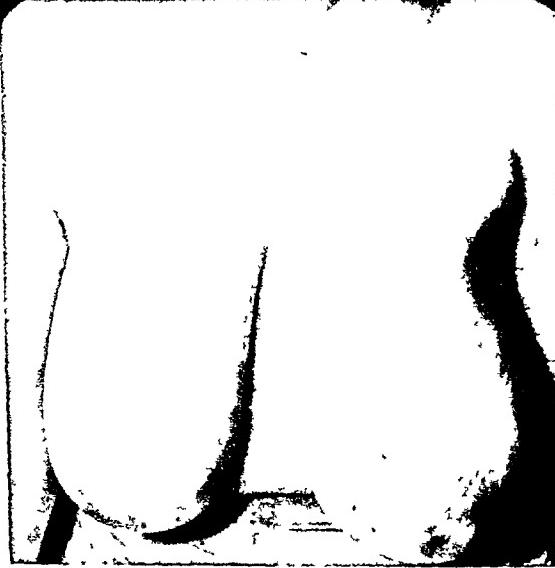


FIG. 4.



Figs 1 to 4. Pendulous breasts of all sizes and shapes are a constant source of annoyance to the wearer not only physically but also mentally.

patients for their operation to advise them to have one or two Dierker colonic irrigations. This helps rid the system of impurities and makes the convalescence less complicated. The patient should take a good hot tub bath, on the night preceding the operation as tub bathing is impossible for a number of days while the incisions

before the operation a hypodermic is given of H.M.C. Mixture No. 1. This is a combination of morphin, hyoscine and cactoid, a heart stimulant. I have used this for many years and find it very satisfactory. I have also used Evipal, and pentothal sodium as a preliminary sedative measure. These operations are now performed in

practically every case under local anesthesia. By employing the modified, simplified, operative technic, nerve block

of the outer region of the mammary gland it gives off a branch which supplies the outer one-half of the breast tissue, the

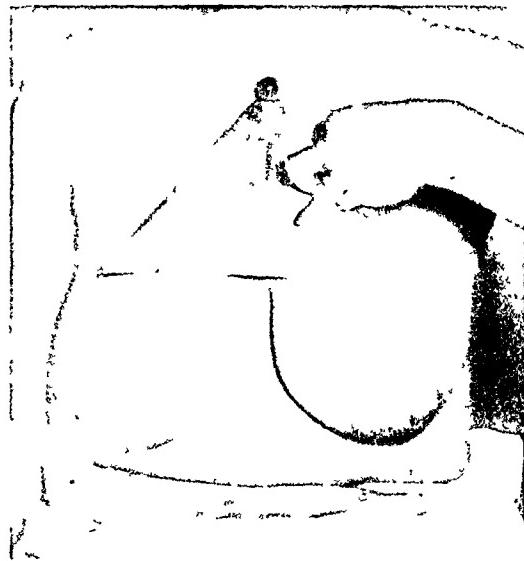


FIG. 5. Triangle suspended from the supraclavicular notch which shows approximately where the nipple should be normally located. By bunching the breast up in the palm of the hand, the correct location of the upper border of the areola of the nipple can be located and marked on the skin. The mark can be made with brilliant green, or better, by injecting a few minims of novocaine, a slight horizontal cut can be made which is not removed when later the antiseptic is applied. It is my custom to make this mark in the office a day or so prior to the date of operation. Everything is done to make the actual operating time as short as possible.

anesthesia is very satisfactory, and allows the surgeon to concentrate on the various steps of the operation.

When the patient is placed on the operating table, the entire chest is painted with a tincture of Ceepryl 1-200. This gives perfect antisepsis which is very necessary in these cases.

Sensation in the mammary area is supplied by the third, fourth and fifth spinal nerves which occupy a notch in the posterior and undersurface of each rib. The artery and vein, which accompany the nerve, are situated in the same notch, but in a higher position. The nerve being lowest is more easily accessible. When the intercostal nerve reaches the region

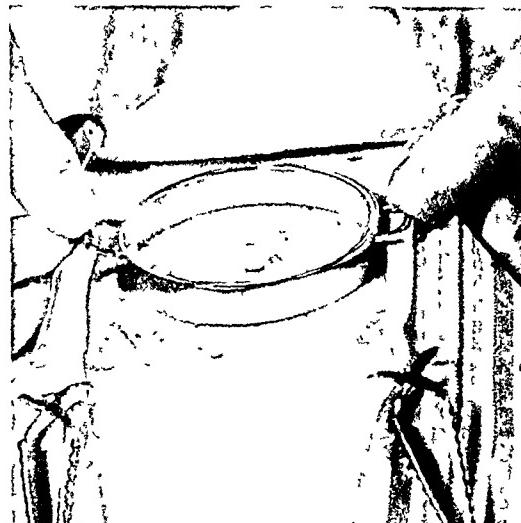


FIG. 6. Supporting ring is placed around the nipple with it in the center. The assistant by using slight pressure will cause the tiny pins on the undersurface to become embedded in the skin and thus keep it from slipping while the circular incision is being made.

main nerve trunk continuing along the border of the rib to supply the inner half of the same gland. The procedure for blocking this nerve is as follows: About in the region of the midaxillary line, the needle is inserted hugging the lower border of the rib. The needle is pointed in and slightly upward, until the posterior surface of the rib has been reached. In this area about 2 cc. of 2 per cent procaine is injected slowly. The same procedure is adopted for each of the third, fourth and fifth ribs, the entire injection for all three not requiring more than one minute.

When properly injected, the anesthesia should be complete, but if it is not entirely successful, it will only take a few moments to inject locally around the nipple and in the neighborhood a few cc. of  $\frac{1}{2}$  of 1 per cent procaine with about 15 to 20 drops of adrenalin to the oz. This can be injected in every case, as it helps diminish the bleeding to a marked extent.

The first step in performing the operating is to cut a circle around the areola, using

the nipple as a center. The radio knife compass, which I perfected many years ago, is still the easiest and quickest to use.

washer was constructed of such a size as would just fit around a large nipple. On the undersurface of this washer, six

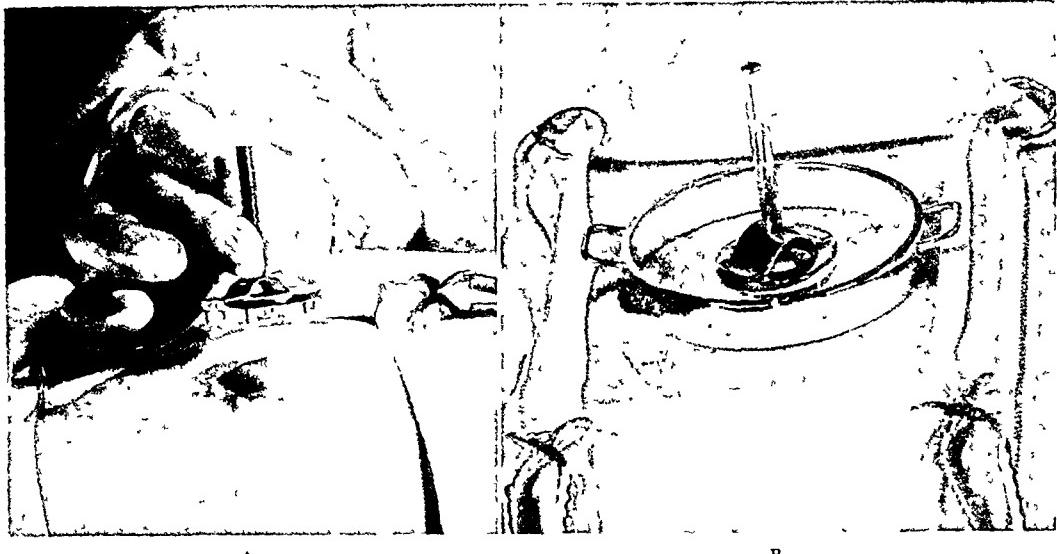


FIG. 7. A AND B, washer with pins on its undersurface, and with a bridge over the nipple supporting a vertical pin is placed directly over the nipple, the pins becoming embedded in the skin and thus supporting it, while the cut is being made.

But in the last few years, I have modified it quite considerably. The original one could make a circle of only a definite diameter. This was a handicap, as cosmetically the circle should be much larger in some cases than in others; and in several men who have had this operation performed it was impossible for me to use the compass at all as the areola was not much bigger than a dime. Formerly, the base of the center rod would rest on the nipple, and this was found to have a tendency to slip in all directions. To remedy these defects, a horizontal sliding bar was constructed to be attached to the vertical support of the compass, and to it another sliding attachment was added which could be held in any desired position with a screw. The sliding attachment was firmly fixed to the part that held the cutting electrode, so that the diameter of the circle could be made any width desired and locked in position. The end of the horizontal rod also serves as a handle when rotating the cutting point while cutting the circle. To prevent the vertical rod from slipping to one side or other of the nipple, a circular

pins were attached, which would penetrate the skin by pressure and prevent slipping. Across the top of this washer a bridge was constructed, covering over the nipple, and from the bridge in a vertical direction a small rod was attached, about  $1\frac{1}{2}$  inches long which could be inserted into the hollow end of the vertical part of the compass. When the compass with its base attached was placed over the nipple and slight pressure made, all slipping of the compass is prevented. (Figs. 6 and 7.)

Another difficulty was formerly encountered in making the circular cut perfect, due to the fact that when the assistant supported the skin with the outstretched fingers around the nipple while the cut was being made, there was a tendency to pull more in one direction than in the other, with the result that in some cases the circular incision became irregularly oval. To overcome this I had about one-half inch of a large brass pipe sawed off to form a ring. On the undersurface of this ring, a series of fine pointed pins were embedded, and on opposite sides a flange was attached which would

enable the assistant to hold it firmly on the skin. In this way the skin was held immovable all around the nipple, presenting a solid flat surface for the cutting procedure.

ring around the nipple with it as its center. Have assistant press it firmly against the skin. Place the little washer over the nipple and insert the pin in the end of

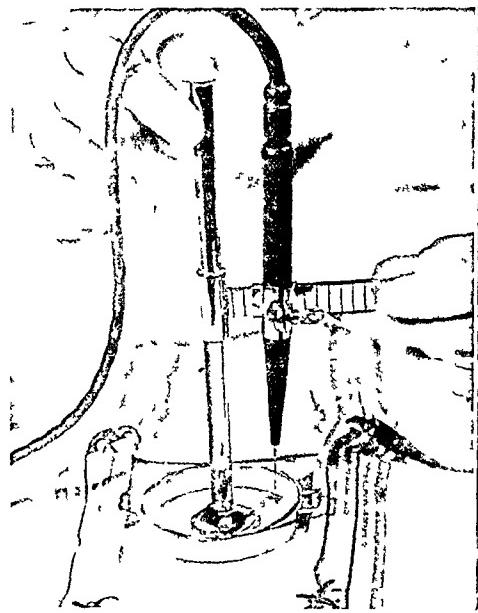


FIG 8 The compass is adjustable so that the cutting point, which may be either a Bard-Parker knife or from an electrosurgical unit, is set according to the width desired, usually the same as the present areola. This is placed directly over the pin on the washer resting on the nipple, firm pressure is made with one hand on the vertical pin, while with the other the circular cut is made with one complete sweep, just through the skin and completely around the nipple. The whole procedure takes less than five seconds. Immediately following the circular incision the entire apparatus is removed.

In cases in which one would prefer using the Bard Parker knife in preference to the cutting current, I had a handle constructed somewhat like the regular Bard Parker handle with a slot through the middle. This could slide on the horizontal bar and be locked in a set position just as the cutting electrode was fastened, and used in exactly the same way. My preference is for the cutting current, as it is more smooth in operation, much easier to manipulate, and the final result is just as good.



FIG 9 The same as in Figure 8 showing the use of a Bard-Parker knife

the compass. Grasp the horizontal handle, press on the foot switch, and with one sweep cut a complete circle through the skin. This is done faster than you can say it. Remove the ring and the compass and with a knife or cutting electrode make a second cut from the lower border of the incision around the nipple directly downward to the chest wall. The length of this incision depends entirely upon the length of the undersurface of the breast. You do not need to be too careful to center this, as the edges are all removed when closing up.

The skin is now denuded from the entire surface of the breast. A Bard Parker knife, Caylor scissors, or any instrument you are familiar with may be used. Care must be used not to puncture the skin and to follow the lines of cleavage. This can be done with practically no bleeding, which is helped perhaps by the presence of the adrenalin and the procaine infiltrating the area. When the skin has been separated completely in all directions, three Lahey

*Operative Procedure.* Place the large

goiter clamps are used to pick up the gland and hold it vertically upward. You now have the gland covered more or less profusely with fat, and the nipple uppermost surrounded by a very much contracted and irregular disc of skin. So far the breast has not been harmed in any way, all the blood vessels and ducts being intact.

The fat may now be removed. While the assistant elevates the breast, being extremely careful not to make any traction on the nipple, the surface fat is sliced off, downward and outward, from the Lahey clamps in all directions. You will now notice that the breast is composed of three parts: First, the base; this seems firmly attached to the chest wall and extends upward in the form of a sort of narrow pedicle, and above this the breast itself, with the nipple and areola resting on the uppersurface. When the breast tissue is greatly oversized, a keystone-shaped section is excised from upper central portion. The tissue is removed clean down to the pectoralis fascia, also other sections may be removed in a radiating direction from the lower portion of breast and edges approximated with chromic catgut. The main arterial supply follows the border of the pectoralis minor muscle and when this artery is severed, the result may be a necrosis of the upper and outer quadrant of the nipple, and therefore should be avoided. Small blood vessels penetrate the intercostal spaces at the border of the sternum and thus supply the mid-portion of the breast. This area should be avoided.

To shorten the pedicle, all that one has to do is to allow the outer part or body of the gland to be superimposed upon its base in its original position, and sutured by means of about six No. 1 20-day chromic catgut sutures. These sutures are placed above and at intervals around the circumference of the base. The Singer sewing machine surgical needle is well adapted for the insertion of these sutures, in which case fine silk may be used.

You now have the mammary gland resting on its original bed and sutured

firmly in its proper position. It remains necessary only to fit the skin snugly around the reduced glandular tissue. The skin



FIG. 10. Vertical cut is then made downward, from the lower border of the circular incision around the nipple, in the mid-clavicular line. The incision extends downward to approximately the lower border of the breast attachment to the chestwall. The incision may be made with the Bard-Parker knife or the cutting point of the electrosurgical unit as desired.

has accumulated in varying quantities and lies in folds. To eliminate this correctly and in just the right amount is another problem. This was solved by the construction of a two-bladed clamp. Each blade has a slot in it which runs almost its entire length. The ends are held together by a screw with a winged nut, one end of which has a slot so that the blades can be widely separated if desired. With the fingers the loose skin is pulled over the breast on both sides as near to the center of the breast as possible and held by the Lahey or Allis clamps. The slotted clamp is now placed around and under them and locked loosely in position.

By manipulation and pulling up and outward on the skin edges, the skin can be made to be quite smooth on both sides of the clamp, with the tension approxi-

mately equal on either side. By pulling the skin in a downward direction, the length of the cut can be materially shortened. When this point has been reached,

cision, a small drain may be inserted, although it is not necessary. Sulfanilamide is dusted over the entire incised area and a dressing applied.

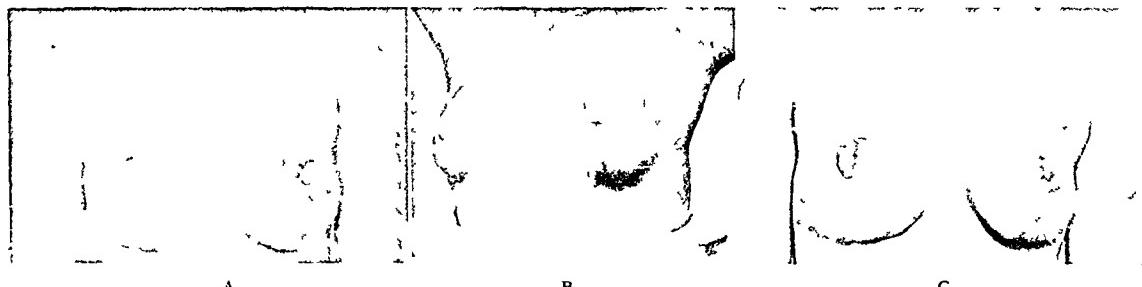


FIG. 11. A, B and C, postoperative views of three patients

the suturing begins. A straight or curved needle may be used with medium heavy silk. It is passed back and forth through the slot in the clamp, so as to form a horizontal mattress suture. Five or six of these may be needed, depending upon the individual breast. No attention is paid to the nipple and areola whatsoever, as it will now be buried beneath the skin. When the sutures have been completely inserted, by the aid of a knife or pair of scissors, the excess skin lying external to the clamp is sliced off, leaving the edges held together in close approximation by the mattress sutures previously inserted.

The final step is to bring the nipple to the surface. Here again we resort to the knife compass. By placing the cutting point about one inch below the upper end of the sewed up incision, the opening slightly larger than the original areolar incision is made. Following this cutting operation, the nipple will be found to emerge directly through this opening and in its correct position. Fine silk sutures are used, individually inserted, one at twelve o'clock, one at six, one at three and one at nine, etc., and so until the areola is circular and properly attached. The cut edges above the mattress sutures can be more evenly approximated by a running light silk suture running the entire length downward. At the lower end of the in-

It is quite essential that proper pressure be applied to hold the skin in direct apposition, to have the pressure evenly distributed in all directions, and thus avoid serum exudation. I have found nothing better than the rubber bags as advocated in one of my previous articles on this same subject. The bags used are the same as are made for the Barnes blood pressure outfit. These are placed upon the surface of the dressings and above this the bandages. The inlet and outlet tubes protrude below the bandage. When those are connected with the blood pressure outfit, and the pressure raised to about 10 to 12 mm. of mercury, the breast will be supported by a cushion of air with the pressure the same in all directions, and the dressing will be found to be very comfortable. For the first day, instead of air, the bag may be filled with ice water under pressure, and changed in several hours; on the next day warm water may be applied in the same manner, or the air pressure idea substituted for the ice water after the first twenty-four hours, one tube on one side being connected with a tube on the opposite side. While the healing is taking place the patient should be quite careful to rest quietly, and not remove the supporting measures for the gland. Downward pressure will cause the incision to widen and thus make the resulting scar more conspicuous.

# RESECTION OF THE STOMACH\*

HOWARD M. CLUTE, M.D.

Surgeon-in-Chief, Massachusetts  
Memorial Hospitals

AND

CHESTER W. HOWE, M.D.

Assistant Visiting Surgeon,  
Massachusetts Memorial Hospitals

BOSTON, MASSACHUSETTS

**I**N this paper we wish to discuss our present-day procedures in the selection, preparation, operation and post-operative care of patients having lesions that require resection of the stomach.

As one's experience increases with the years, one notes that the frequency of surgery in duodenal ulcer has distinctly diminished in direct proportion to the opportunity that these patients have for good medical management. In common, now, with other surgeons and gastro-enterologists, we find that the great majority (85 to 90 per cent) of all our duodenal ulcers can be handled medically. When complications occur in duodenal ulcers, however, surgery is very definitely indicated, and it is our belief that at times we are *over-cautious* in recommending surgery in certain of these cases.

## MANAGEMENT OF GASTRIC RESECTIONS

Of course, in acute perforation of a duodenal ulcer, every one agrees that immediate surgery is indicated, and we believe that in these cases our first concern is the prevention of a spreading peritonitis and not primarily the treatment of a duodenal ulcer. Therefore, we do nothing more than close the ulcer, and if at a later date further ulcer symptoms develop, or if pyloric obstruction occurs, it is then the proper time to consider whether further surgery is indicated.

In marked fibrous pyloric obstruction from a long-standing duodenal ulcer, we believe that surgery is indicated. In the past we were of the opinion that posterior gastro-enterostomy or gastroduodenostomy might well be used in these people, and not

infrequently we still use these procedures. If the patient is old and feeble, we have found from careful follow-up studies that gastroduodenostomy for fibrous obstruction of the pylorus gives excellent, long-standing results.<sup>6,7</sup> Occasionally, in patients with pyloric obstruction, there is an undue delay in determining whether there is edema from infection and pylorospasm, or whether there is an actual fibrous obstruction before surgery is requested. It is our belief that unless the obstruction at the pylorus can be overcome in a week or ten days by medical management that the case should, without further delay, have surgical interference. Continuing medical management in the face of pyloric obstruction for several weeks serves only to deplete the patient's vital resources, and when it is at last applied, makes surgery more dangerous.

Certain patients with ulcers should be operated upon because they do not respond to medical management. These medical failures may be due to idiosyncrasies or to failure of the patient intelligently to follow the treatment outlined. In such cases we believe very strongly that when surgery is indicated, a short-circuiting procedure should not be used, but that high subtotal resections of the stomach are definitely indicated. It is in this group of cases that the internist and the surgeon must co-operate most closely and must have a thorough understanding each of the other's abilities to deal with the problem in question. It is but natural that internists should be loath to turn over ulcer patients for surgery until the indications for surgery are more than completely fulfilled. This is due to the fact that in the past the mor-

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tality from resections of the stomach has been high. As surgeons improve their technic and this mortality reaches the very low and very reasonable figure which it should approach (i.e., under 5 per cent in our experience), it is to be expected that the internist will turn over these debatable cases at an earlier stage for surgery. In this disease, as in many others, surgeons have had to prove their competency.

The question of repeated bleeding as an indication for surgery has many angles for discussion. We are inclined to believe that when an ulcer patient is past middle life and has had repeated serious hemorrhages, he has, in all probability, an ulcer of the posterior wall of the duodenum, which experience shows will not do well with medical management. Assuming that he is in good condition, a resection of the stomach is usually desirable. In young people with one or two hemorrhages, we are inclined to continue with medical management.

As we see it, the real problem for the surgeon is the consideration of immediate surgery in the patient past middle life who comes into the hospital more or less exsanguinated by a severe hemorrhage from the stomach. We have found it hard to convince ourselves that such critically anemic patients should be subjected to immediate subtotal gastrectomy. A man of sixty-five with an indurated, acutely inflamed duodenal ulcer which has bled so badly that his hemoglobin and red cells are markedly reduced, presents, in our hands, a very poor risk for radical gastric surgery. It must be remembered that surgery in these individuals must consist of a radical resection of the ulcer, if we are going to accomplish control of the fundamental difficulty, which is severe hemorrhage from the bed of the ulcer. We prefer in these individuals to risk medical management for a period of weeks or months and improve their general condition. We then can review the situation with the idea of resecting the stomach at that time, if it seems desirable. We have not yet been convinced that radical gastric surgery in the presence of an

acute hemorrhage in an old person is the procedure of choice.

The final indication for surgery in peptic ulcers is the question of possible malignancy in the ulcer. This, of course, applies almost entirely to lesions of the stomach, although occasionally the roentgenologist cannot be sure whether the lesion is pyloric or duodenal.

While surgeons have become increasingly conservative in their acceptance of duodenal ulcer patients for surgery, it seems to us that they have perhaps become over-conservative in their acceptance of patients having gastric ulcers. When one considers the incidence of malignancy<sup>1</sup> in gastric ulcers, depending on the location of the ulcer, one must seriously consider more frequent radical resections. Allen<sup>1</sup> reports a diagnostic error of 14 per cent in 277 cases. In our clinic we are becoming increasingly anxious to operate upon gastric ulcers at an early stage after their diagnosis, rather than spend weeks in delay for accurate diagnosis of the type of lesion. We are completely convinced that our only hope of getting ahead of cancer of the stomach is to operate more frequently on ulcers of the stomach. By doing this we may remove a few ulcers which are benign and which perhaps would have healed. We believe, however, that this is of relatively little importance, since, at the same time, we undoubtedly shall have removed certain very early malignancies which otherwise would have spent weeks in developing before they were operated upon. One must not forget that many gastric cancers go from debatable lesions to inoperable growths in a few weeks.

Our general tendency, then, in the selection of patients with peptic ulcer for surgery is to become increasingly conservative in the advice for operation in duodenal ulcers, and to become increasingly radical in advising surgery for all gastric ulcers.

The selection of any patient for gastric resection requires on the part of the surgeon not only careful information as to the

precise reasons for gastric resection, but also requires a consideration of the patient's age, nutrition, cardiovascular status, anemia, and protein reserves. It has become increasingly apparent to us that the matter of old age is no absolute contraindication to gastric resection, since several of our patients in their late sixties, early seventies, and even one over eighty, have done well with gastric surgery. The state of the patient's nutrition and the degree of anemia, however, are of great importance and are some of the details of preoperative management that should require particular attention. The cardiovascular status of the patient is also highly important. Patients who have had coronary infarcts, chronic asthma or bronchitis make very poor operative risks; and in these patients, if cancer can reasonably be ruled out, one must use prolonged medical management before advising surgery.

#### PREOPERATIVE CARE

The preoperative preparation of the patient for gastric surgery may require several days or even weeks and demands particular attention to details. Inasmuch as these cases usually fall under the category of elective surgery, adequate time should be taken to secure optimum conditions, and the more meticulously careful we are at this stage, the better the convalescent period will be.

Particular attention is paid to the correction of anemia and hypoproteinemia. One or more transfusions are given preoperatively. It is our experience that the red cell count is not materially elevated after transfusions subsequent to the first one or two. We, therefore, resort to the additional use of plasma transfusions and intravenous amino-acids to restore the protein stores.

In anticipation of possible multiple transfusions it has been our custom recently to have Rh factor determinations done preoperatively on all contemplated gastric resections. On several occasions we have encountered Rh negative patients,

and thus were able to avert possible transfusion reactions.

Finally, on a few of the more debilitated patients with low serum protein we have performed preliminary jejunostomies for pre- and postoperative jejunal feedings. This, of course, makes the gastrectomy somewhat more difficult if done preoperatively; but in addition to affording a means of restoring protein, it affords a chance to explore the stomach at the time of the jejunostomy. The patient is given a simple peptonized jejunostomy formula<sup>3</sup> through the tube and, in addition, amino-acids can be administered in this way.

We are in the habit of having a liter of compatible blood available in the room at the time of operation; and if the patient has poor veins, we insert a cannula into one of the ankle veins to facilitate intravenous therapy during the operation.

A careful dietary history and blood cevitamic acid levels preoperatively give useful information regarding the vitamin C needs. This is administered in the form of 100 mg. cevitamic acid tablets three times a day by mouth if there is no obstruction. If there is obstruction, we give it in the intravenous fluids in greater amounts (500 mg. daily) to allow for some spillage in the urine. Prothrombin time values are also performed routinely and parenteral vitamin K is administered when indicated.

Needless to say, each patient is carefully evaluated as to his cardiovascular-renal status. Even in the absence of frank cardiac disease a routine electrocardiographic tracing and cardiac consultation are obtained to serve as a base line and aid to the consultant later, in the event of possible pulmonary or cardiac complications. Occasionally, the differential diagnosis between coronary disease and pulmonary embolus is a difficult one and a preliminary electrocardiographic tracing is a welcome aid.

Similarly, a routine preoperative chest film is taken, not only to rule out metastasis in cancer cases, but also to serve as a comparison film later in the event of pulmonary complications. Although non-

protein nitrogen determinations are routinely carried out, we believe, as Graves and Militzer<sup>8</sup> have pointed out, that a carefully done phenolsulphonphthalein excretion test is a much finer index of early renal damage and serves as a warning to greater care in fluid and electrolyte balance consideration.

In cases with pyloric obstruction in which there is a large gastric residue, we place the patient on a constant Levine tube drainage with Wangensteen suction for some days. We also administer maximum doses of vitamin B and C parenterally. This serves not only to cleanse and decompress a dilated stomach but also reduces the edema and prepares a stomach for a much easier operation. Not infrequently this regimen will serve to reduce edema sufficiently to allow the passage of food through a previously completely obstructed pylorus. The tube can then be removed and nourishment given orally for several days before operation.

All patients for gastric resection have a Levine tube in the stomach with suction for twelve hours or more before operation and come to the operating room with the tube in the stomach. During the operation, suction may be applied to this tube, as needed, to empty retained fluid.

#### OPERATIVE PROCEDURE

The type of anesthesia for gastric surgery will vary in each clinic with the preference of the surgeon and more particularly with the ability of the anesthetist who works with him. The use of the same anesthetist by a surgeon in all his more difficult cases has many advantages. Each learns to know the other's technic and is, therefore, much better able to co-operate with the other. Certainly if we could have but one person regularly on our surgical team, we would choose an expert anesthetist for this position.

We prefer spinal anesthesia for all our cases of gastric resection. In our opinion, the increased speed and ease of operation more than offsets its dangers. No fatalities

or fatal complications in our recent experience can be laid to spinal anesthesia.

Recently, our anesthetist has been using continuous spinal anesthesia, following the technic of Lemmon,<sup>9</sup> and this has been the most satisfactory anesthesia we have yet enjoyed. The advantages of continuous spinal anesthesia, as we see them, are not only related to the fact that in prolonged procedures the surgeon may have persisting complete relaxation of the abdominal muscles, but also to the fact that in certain cases in which exploration shows that the gastric lesion is inoperable, the anesthesia can be readily terminated. Occasionally, in the long cases with continuous spinal anesthesia, the patient must be given pentothal intravenously or some gas-oxygen anesthesia to abolish traction reflexes and to avoid general discomfort.

#### TECHNIC OF RESECTION

In recent years there has been a tendency to pay relatively slight attention to a discussion of the actual technic of operative procedures and to spend increasing time in consideration of the physiological factors involved in the disease proper. We believe that good technic and manual dexterity are essential to a surgeon, and that the precise methods of carrying out the technical procedures of an operation are still of great importance to all of us. We wish to discuss in detail the technic that we follow:

For patients upon whom gastrectomy is anticipated, we make a long incision, which varies from the right to the left side of the abdomen, depending upon whether the major lesion is in the pyloric end of the stomach or duodenum, or whether it is in the lesser curvature or fundus of the stomach. If the malignant lesion is high on the lesser curvature, we at times find it desirable to cut the costal cartilages on the left side in order to obtain increased exposure.<sup>4</sup>

In considering the technic of gastric resections we wish, first, to discuss our technic for resections of the stomach for

cancer. The abdomen being opened and the lesion being found operable, we start by removing the greater omentum from the colon. This can be very rapidly done, only a few blood vessels will need to be tied, and on its completion the great mass of the omentum, the greater curvature of the stomach, and the stomach itself can be readily lifted up. This permits access from behind to the left gastric artery high on the lesser curvature, if desired, and it permits ready observation of any involvement of the pancreas in the tumor before one has ligated the major arterial supply.

The gastrohepatic omentum is now entered with the fingers and radically removed, clamping the vessels as they are encountered. One may now divide the main blood supply high up on the lesser curvature, well above the region of the malignancy, and approach this either from in front of or from behind the stomach.

The vessels above and below the pylorus are now caught and cut, and the duodenum is brought into view where it can be readily and safely clamped. For cutting the duodenum we first place our own modification of the Furniss clamp<sup>3</sup> on the duodenum with an Ochsner clamp above it, and divide the duodenum just beyond the pylorus with the actual cautery. With the modified Furniss clamp the closure of the duodenum can be accomplished without soiling and in very short time. The covering of the clamp on the distal end of the stomach by a piece of Penrose tubing, as recommended by Taylor,<sup>10</sup> quickly takes care of this possibly soiled area. With multiple fine silk sutures the duodenum is now closed by turning in the ligated cap with at least two layers of mattress sutures. Finally, it is folded over into the head of the pancreas with more silk sutures.

The stomach and the attached duodenum are now lifted high out of the abdomen and an anterior Pólya type of anastomosis with the jejunum is made. We have thus far not used an "aseptic" anastomosis, but as much soiling as possible is avoided by the use of rubber-

covered clamps and careful draping of the area with wet pads. When a total gastrectomy is done, the jejunal loop is held against the diaphragm and then anastomosed, end-to-side, to the esophagus.

Resection of the stomach for duodenal ulcer is carried out by much the same technic as for cancer of the stomach except that the omentum is not covered in its entirety and a much less radical removal of the gastrohepatic omentum is necessary. In all our resections for ulcer two-thirds or more of the stomach is removed.

It is essential in every case that the pyloric mucous membrane be removed. We prefer, if possible, to remove the pylorus itself and almost invariably we can do this. Attempts at removing the mucous membrane and sewing over the pyloric muscles are apt to result in a wad of tissue at the pylorus, the closure of which may be unsatisfactory.

In most instances the duodenal ulcer is removed in the resection. In some cases, however, the ulcer is so edematous and so close to the common duct that removal of the duodenum containing the ulcer seems to us to be too dangerous. We have no hesitation in these cases in leaving the ulcer behind, provided the pyloric end of the stomach is completely removed. We have not encountered later trouble from these cases and believe this is safer than any radical attempt to remove an ulcer involving the common duct.

As in resections of the stomach for cancer, the method of closing the duodenum is one of the most important details of the operation. Failure to obtain a satisfactory duodenal closure is very likely to result in a leakage and serious trouble, if not a fatality.

The anastomosis between the stomach and the jejunum is carried out by bringing the jejunum anterior to the colon in almost all of our recent cases. We have had less trouble with postoperative vomiting and difficulty since doing anterior Pólya's than we had previously with posterior Pólya operations. Occasionally, when the jejunal

mesentery is short and when the omentum is heavy, it is necessary to resect a piece of omentum from the colon in order to make it possible to bring the jejunal loop up to to the end of the stomach.

In all of these anastomoses we use two layers of sutures, the inner layer being catgut, with a baseball stitch, the outer layer being continuous silk.

In patients who have had obstruction, who have had hypoproteinemia preoperatively, who have lost weight and are generally depleted, we do a jejunostomy<sup>5</sup> for postoperative feeding, as soon as we have finished the Pólya anastomosis. This jejunostomy takes only three or four minutes and thus far has not been the source of any postoperative difficulty.

We now use sulfanilamide powder in the abdominal cavity around the suture line, around the duodenal stump, and in the abdominal wound in all resections of the stomach. Anglem and one of us (H. M. C.)<sup>2</sup> recently reviewed the results of this procedure in a large group of gastric and intestinal resections. In no case in which death occurred was peritonitis present. We are convinced that this is a great addition to the surgery of gastric resections, and that placing this drug in the peritoneal cavity is better than giving it by mouth because of the high concentration obtained in the local area of soiling. The amount of sulfanilamide powder that we use varies, of course, with the size of the patient, but, on an average, consists of 8 Gm.

In most patients we close the abdomen by first placing through-and-through heavy silk stay sutures which pass through all layers of the abdominal wall and which are spaced three-quarters of an inch apart. After these are placed, the various layers of the abdominal wall are sutured with short continuous catgut sutures and the stay sutures are then loosely tied. We use No. 0000 catgut for the ligation of all vessels in the abdominal wall and No. 0 chromic catgut for the peritoneum, transversalis, and rectus fascia. With this method we have had no ruptured wounds,

and infection has been so rare and so mild as to be unimportant.

#### POSTOPERATIVE CARE

Meticulous postoperative care begins as soon as the patient leaves the operating room. The anesthetist accompanies the patient back to the ward and arranges his position in bed, orders the indicated parenteral fluids and personally inserts the nasal tube or arranges the oxygen tent and leaves the patient with a clear airway. The Levine tube, still in place, is immediately attached to Wangensteen suction.

We are convinced that two of the most important factor in successfully bringing a gastrectomy patient through the post-operative period are adequate and constant nursing care and a vigilant house staff constantly on the alert for possible complications. Whenever possible a special nurse is obtained. On ward cases this is made possible through a special fund which we have at our hospital for this purpose.

Careful precautions are taken to prevent atelectasis. The patient's position in bed is changed hourly from side to side and the patient is encouraged to cough. If it is evident that there are excessive secretions collecting in the trachea and bronchi, we resort to thumping the patient's back with the open palm while supporting the area of the incision with the opposite hand. The attending nurse is carefully instructed in this procedure and the patient is awakened each hour to change his position and thump his back. This may perhaps seem a little cruel at times, but the results are gratifying. This maneuver is carried out, first, with the patient on one side and then on the other and is continued until the specimen of mucus is raised. Following this, carbon dioxide is administered for one or two minutes, either by paper bag re-breathing or direct carbon dioxide oxygen inhalations with a bedside tank and mask. In the event that the mucus cannot be raised by encouraging coughing and back thumping, the pharynx and trachea are aspirated, using a small nasal catheter and

a bedside suction apparatus. Rarely is it necessary to resort to local anesthesia of the pharynx for this purpose and with a little practice the catheter can almost invariably be manipulated into the trachea. The stimulation of the procedure often causes expectoration of the mucus. On the rare occasions when this method fails and atelectasis is present, the patient is taken to the operating room and the secretions are removed by direct bronchoscopy.

A Levine tube left in place for any length of time is a hazard and predisposes to upper respiratory infection. For this reason we frequently remove the tube on the second or third postoperative day. This affords the patient much comfort and we believe that there is no danger in reinserting the tube each morning and evening for a few days to determine the amount of gastric residue. If it is necessary to leave the tube in longer, just removing it temporarily for a few hours or for the night affords considerable relief. Frequently anointing the Levine tube with Nupercaine ointment is another measure which makes it much less offensive to the patient and cuts down pharyngeal irritation. While in place, the Levine tube is irrigated every two hours with 20 cc. of saline to insure its patency.

The high spinal anesthesia used for gastric resections usually paralyzes the intercostal nerves at least up to the fifth dorsal area. In over half of our cases sodium pentothal is used as a complementary anesthetic to abolish traction reflexes. Thus, the central respiratory depressant effect of the sodium pentothal and the high spinal anesthesia usually result in rather shallow respirations. For these reasons our anesthetist starts the administration of oxygen during the operation and this is continued immediately on putting the patient back to bed, by means of nasal oxygen or a small oxygen tent, as a supportive measure to insure adequate oxygenation of the blood.

Our patients are given water by mouth on the first postoperative day in small

amounts (1 dr. every one-half hour). On the following day this is increased to 2 dr. every half-hour, and by the third day they are taking 2 ounces an hour. This can do no harm because most of it comes back out through the Levine tube and it is a great comfort to the patient. Our diet rapidly increases from this point onward so that malted milk is taken on the fourth and fifth days, gruels, jello and custards on the sixth, and fluids as desired, with soft boiled eggs and cooked cereals by the seventh day.

Supplementary vitamins are administered in the intravenous fluids and intramuscularly until the patients can tolerate them by mouth.

A careful and frequent check of the red cell count, blood chloride, cevitamic acid and total protein levels serves to guide us in the administration of intravenous fluids, whole blood, plasma, and amino-acids. We try to maintain a fluid intake of at least 3,000 cc. daily and a urinary output of over 1,500 cc. In elderly patients and especially in those with cardiovascular-renal disease or low protein levels we guard especially against giving too much saline solution.

If the patient has had a jejunostomy, the formula is started in from twenty-four to thirty-six hours postoperatively. Unless peristalsis is completely absent, we inject from 25 to 50 cc. of water or saline into the jejunostomy tube every two hours, beginning eight or ten hours postoperatively. The following day the formula<sup>5</sup> is started, diluted half and half with saline, giving 50 cc. of this every hour. If this is tolerated well, if peristalsis is present and there is no distention, it is increased to 100 cc. an hour, and the next day the full strength formula is used. In order to utilize the electrolytes and gastric secretions lost by suction, these also are mixed with the formula. By gradually accommodating the bowel to the formula we have had excellent success. Patients on this regimen usually have two or three soft bowel movements a day, but we have had little trouble with

diarrhea and have been able to deliver about 2,000 cc. of formula each twenty-four hours, which gives the patient 1,520 calories.

It is essential that the formula be made up in small, fresh lots daily and that it be warmed to body temperature before giving it. We deliver it through a Kelly flask, with a large rubber tube leading to the jejunostomy and regulate the flow by means of an air bubble water chamber attached to the top of the Kelly flask.

The large size of the delivery tube prevents coagulation and it is essential that only small amounts of formula be placed in the flask at once and that the apparatus be cleansed and boiled daily to prevent souring.

If a patient has to be catheterized more than twice postoperatively, an indwelling catheter is left in place and sulfadiazine is given prophylactically in small doses.

On the first or second day postoperatively systematic leg exercises to prevent thrombophlebitis are instituted and if an intravenous cannula has been placed at the time of operation, careful attention is given to the wound to prevent sepsis.

We have had cases in which the gastrojejunal stoma was delayed in assuming its function and these have been successfully handled by beginning over on the ascending diet scale, meanwhile relying on the jejunal feedings or intravenous therapy for nourishment.

Skin sutures are removed on the ninth day. In cases in which a muscle-splitting incision is used, the through-and-through braided silk sutures are left in place until the patient is up and are removed on the twelfth to fourteenth postoperative day. The usual gastrectomy patient is allowed to "dangle" on the eleventh or twelfth

day and is out of bed on the thirteenth or fourteenth postoperative day.

#### SUMMARY

It is apparent from the foregoing that the successful management of gastric resections demands not only a skilled surgeon, anesthetist and operating team, but also the most painstaking preoperative and postoperative care by the hospital personnel. Years ago we found that the reduction of mortality in operations for hyperthyroidism came only when the internist and the anesthetist united with the surgeon in a study of the disease and its mortality-producing factors. Similarly combined efforts are now bringing the mortality of gastric resections to a figure which permits the medical men to recommend surgery for peptic ulcers when they first suspect it may be necessary.

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# COMMON KNEE INJURIES

## SOME ASPECTS IN DIAGNOSIS AND TREATMENT

CAPT. WALTER A. DALMAIN

MEDICAL CORPS, ARMY OF THE UNITED STATES

THE knee joint is important as an industrial and compensation problem. In the Army the orthopedic surgeon is confronted with all the problems in reference to the knee joint that one finds in civilian life, plus the great increase of injuries due to the nature of the soldier's training and actual combat duties.

The three most important conditions resulting in internal derangement of the knee joint are traumatic synovitis, tear of the menisci, and osteochondritis dissecans. The percentage of new injuries seen in the Army is high. Chronic knee conditions are usually old injuries received in civilian life which may have become aggravated by military service.

A young man who worked as a clerk or a salesman and who is suddenly placed in a strenuous basic training course is prone to knee injury. The athlete who has suffered injuries to his knee prior to induction may in the course of the first three months of army training report on sick call because of a painful knee. However, many athletes with knee injuries compensate for such during basic training by their agility and excellent ligamentous and muscular development about the knee joint.

In the Navy these same conditions exist but to a lesser degree. If the Navy recruit gets by his basic training period, he has less likelihood than a soldier of future knee injury. The terrain and the nature of the soldier's duties favor injury to the knee.

Traumatic synovitis, when it occurs repeatedly, may result in a chronic arthritic knee joint producing a severe disability for full duty. The synovial membrane of the knee joint has been classified<sup>1</sup> into three main types, namely, the fibrous, the adipose, and the areolar. There is an abundant blood supply especially in the areolar type

of subsynovial tissue, while the adipose type is moderately supplied and the fibrous type least supplied with blood. Albumin, globulin, and mucin are normal constituents of the synovial fluid which is a clear, yellow, oily fluid formed by the cells of the synovial lining. The mucin which forms a basis for the lubricating action distinguishes the synovial fluids from body fluids which are plasma dialysates.<sup>2</sup> The stimulus for the production of normal synovial fluid is motion. Thus, after a period of prolonged immobilization the joint becomes relatively dry, and this leads to degenerative changes in the articular cartilage and stiffness of the joint. In trauma blood frequently escapes into the joint. If the collection of blood is large, a portion of the hematoma may remain, eventually becoming organized and forming adhesions.

The layman usually refers to the painful, swollen knee due to acute traumatic synovitis as "water on the knee." A few pertinent statements about the treatment of this common condition are necessary. The anatomy of the knee joint is such that when it is filled with fluid a cavity (quadriceps pouch) extends several inches above the patella and its tendon and posteriorly over each condyle. One can visualize how it is possible for a large amount of fluid to be accumulated in the knee joint in traumatic synovitis. One hundred to 200 cc. of serosanguineous fluid is frequently aspirated.

There should be a routine method of treating traumatic synovitis of the knee joint. The usual cause is a sudden twisting motion as in going over an obstacle, immediately, there is pain followed by swelling. The treatment which has been most beneficial in the majority of these injuries

is as follows: (1) Roentgenograms of the injured knee and the opposite one for comparison; (2) aspiration; (3) compression

local areas of the fibrocartilage<sup>5</sup> with a resulting partial split or degeneration which would make the cartilage more vulnerable



FIG. 1.

FIG. 1. Osteoarthritis, traumatic, right knee, severe; result of repeated traumatic synovitis.  
FIG. 2. Osteoarthritis, traumatic, right knee, severe; tunnel view.

dressing; (4) complete bed rest with the extremity elevated; (5) analgesia, and (6) physiotherapy after the effusion has subsided. The knee should be aspirated in the usual manner with an attempt to get all the fluid out by compressing the sides of the knee joint. A compression flannel bandage is then applied extending from the middle of the leg to the middle of the thigh. Elevation of the extremity with the knee straight or in traction with Buck's extension should be maintained for approximately five days. When the effusion has subsided, physiotherapy can be instituted.

The above procedure, if properly carried out, may help to prevent an acute condition of the knee from being transformed into a chronic painful knee due to adhesions caused by organized hemorrhage. In the event the effusion recurs another aspiration may be necessary. The surgeon upon opening into the synovia very often will see these residual adhesions in a patient's knee who in the past has had several episodes of traumatic synovitis.

A soldier with a history of trauma to the knee joint may have sustained injury to



FIG. 2.

to a tear with a new injury. A patient with this history is usually a candidate for operation. Preoperatively, a diagnosis of a ruptured meniscus with displacement is most likely if on physical examination there is limitation of complete extension, and tenderness at the medial compartment of the knee. The other signs, such as effusion and atrophy of the quadriceps muscle, may or may not be present. When a dislocation of the meniscus occurs, it is at the anterior, the posterior, the central, the entire meniscus or it may reveal only a generalized laxity. Roentgenograms taken for soft parts may be of value if one is familiar with this type of examination. Vacuum studies and the injection of oxygen into the knee joint have been reported by some investigators as useful diagnostic aids. The oxygen method is not without danger to the patient. The history and physical examination are the most important factors in determining operative intervention.

During basic training a soldier who never had any pre-existing knee injury may traumatize his knee by either stepping into a hole, falling over an obstacle, kneeling

down, taking part in authorized athletics, or in a motor vehicle accident. The usual story is as stated above and the mechanism

disease, traumatic arthritis involving the femur and tibia, or arthritic changes in the patella. Figures 1 and 2 are roentgenograms



FIG. 3.

FIG. 3. Osteochondritis dissecans, tunnel view, fragment ready to separate.  
FIG. 4. Traumatic loose body attached to tibial plateau; lateral view.  
FIG. 5. Loose fragment 2 cm. by 2 cm. removed from intercondylar space.



FIG. 4.



FIG. 4.



is the opening of the medial joint space. The leg is abducted upon the thigh causing the medial meniscus to become lodged between the tibia and femur. The combination of a tear and dislocation of the meniscus usually results in locking. This, however, may be momentary and the soldier frequently unlocks it himself. If unsuccessful, he seeks medical aid and the surgeon may elect to unlock the knee by manipulation with or without anesthesia. The soldier may never come to surgery and go on to do full duty without another knee injury.

The soldier who has suffered a knee injury prior to induction presents a different problem. A recurrence of his old knee injury may take place. On physical examination the quadriceps muscle is usually atrophied and weakness is noted upon resistive extension tests. There may be tenderness over the medial joint space and moderate effusion. In this type of knee injury roentgenograms are frequently helpful. One may find a Pellegrini-Stieda's

of a severe traumatic arthritis of the knee in a soldier who had served over twenty-three years in the Army where he sustained twisting injuries to his right knee with resulting synovitis. His disability is considered severe because of the arthritis in only one knee which permanently disabled him.

A large percentage of knees will show osteochondritis dissecans in early and late stages. Repeated trauma producing synovitis not properly treated and repeated injuries to the joint or nearby bone will cause changes in the cartilaginous surface. The articular cartilage instead of being smooth, moist and whitish becomes rough and dry with occasional fissures. Mucoid degeneration occurs, and with continued wear and tear, the articular cartilage may be worn off so that the subchondral bone is the articulating medium. This is the beginning of a chronic arthritic knee. Loose bodies may be extruded into the joint cavity by the breaking off of fragments either of the cartilage or marginal osteo-

phytes. Osteochondritis dissecans is a form of aseptic necrosis originating from any area in the knee, be it the patella, femur

dritis dissecans in the same stage of development.

In many injuries to the knee a fragment

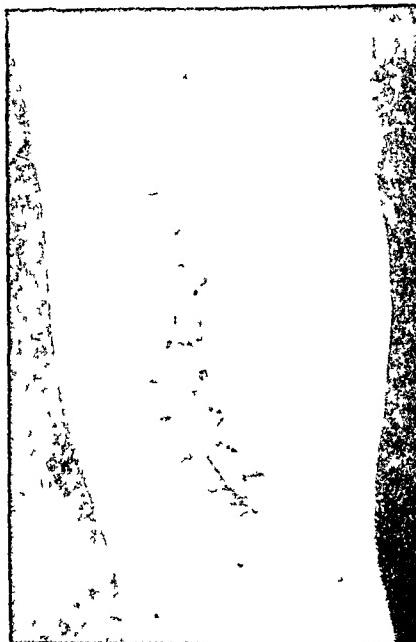


FIG. 6 Parapatella incision, distal portion of general utility incision.

or tibia. The most common area is on the femoral condyle. It may be attached firmly in the early stage with a film of very thin fibrocartilage covering it, or there may be a definite lacuna. Figure 3 is a roentgenogram of a knee in a patient twenty years of age with nine months of service in the Army who gave a history of having been struck in the back of his knee two years prior to induction. During basic training while drilling, marching, and taking part in calisthenics, he had the feeling that his knee was "giving way." On admission there was restriction of flexion to about ninety degrees, tenderness over the medial compartment, one-half inch atrophy of the quadriceps muscle and moderate swelling. At operation the osteochondritic body was easily removed from its bed on the femoral condyle. The microscopic pathological report was as follows: "The articulated bone shows thickened and sclerosed trabeculi, fibrosis of the marrow, vascularization and fraying of the articular cartilage." On occasion one may see bilateral osteochon-

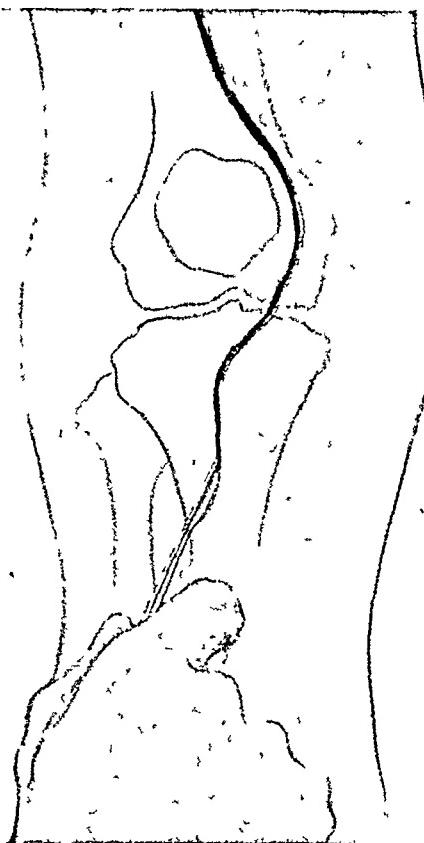


FIG. 7. General utility incision; diagrammatic sketch. (A. KRIDA. *J. Bone & Joint Surg.*, 15: 897, 1933.)

of bone originating from the tibial plateau can be considered as a loose body not due to aseptic necrosis. Figure 4 is a roentgenogram revealing a traumatic loose body caused by an injury received in an automobile accident. Figure 5 is a photograph of the loose body which was removed. The usual joint mouse is a smooth body about the size of a lima bean composed of cartilage. Roentgenograms should be taken immediately prior to operation in order to localize the loose body. Other calcified bodies reported from the roentgenogram examination may be attached to the synovial membrane. The above types of osteochondritic bodies should be distinguished from the condition known as osteochondromatosis.

When it has been decided that an operative procedure is necessary, what is the type of incision to use? What is the post-operative care? What is the reconditioning program to which the soldier must be subjected before he is fit for active duty? The operation is only part of the treatment. The postoperative treatment is extremely important. Contrary to what some individuals have said, there are very few so called "gold bricks" who come to surgery. We are careful to select for surgery patients who give a good history and who present positive physical signs. We have seen an occasional patient who desired to remain in the hospital a little longer, and who complained about his knee without any apparent cause. This type of patient is usually placed on the reconditioning program where special remedial exercises and psychotherapy are instituted. The average soldier realizes that the knee joint is important and that in order to obtain a good functional knee he must co-operate with the surgeon. He usually exercises and after a short time sees the benefits. It has been the misconception of the layman that a stiff knee will result from operation. Consequently, when these soldiers are placed on a ward where they see other recent postoperative patients being reconditioned, they will do everything possible to get motion and to develop the quadriceps muscle.

The condition which the surgeon expects to find should determine the incision employed. The incision should permit full exposure. In derangement of the medial meniscus the incidence is approximately ten times that of the lateral meniscus. The rupture encountered most often is the so-called "bucket handle" type which is a longitudinal tear with the medial half displaced in the intercondylar notch while the other half remains attached. The parapatella incision is the one most often used for excision of the medial meniscus by the general surgeon. Figure 6 is a photograph of the parapatella incision. However, the general utility incision as described by

Dr. Arthur Krida,<sup>3</sup> in 1925, gives a good exposure to the entire knee joint, and when the diagnosis is doubtful this incision



FIG. 8. General utility incision three weeks old; note small incision from previous operation.

will be of great help. Figure 7 is a diagrammatic sketch of the general utility incision. The author describes his incision for exploration of the knee joint as follows: "With the limb extended the incision is begun four inches above the patella in the line between the rectus femoris and the vastus internus passes downward to within one-half inch in the superior border of the patella then sweeps inwardly around the patella about one-half inch from its inner border, then downward to the tibial tubercle. The quadriceps pouch is then explored after which the patella is dislocated outside the external condyle and the joint flexed to ninety degrees, when the rest of the joint cavity becomes visible. It may sometimes be necessary to split partially the infrapatella pad of fat to explore fully the external compartment." When one suspects more than a tear of the meniscus, the lower half of the general utility incision may be made and if the disorder is found that will be sufficient exposure. However, the lower half may be

extended upward and the general utility incision completed for more exposure. This is often necessary in osteochondritis dissecans and where involvement of the patella or hypertrophy of the synovial membrane has been found. Figure 8 is a photograph of a recent postoperative knee in which osteochondritis dissecans and superficial degeneration of the articular cartilage of the patella were found. This patient had a previous operation for excision of the medial meniscus overseas. Note the small incision for menisectomy.

Dr. David M. Bosworth,<sup>4</sup> in 1937, described an incision for exposure of the anterior and posterior compartment of the knee joint through a single skin incision and a double capsule incision, avoiding the possibility of injury to the patellar branch of the saphenous nerve and the presence of a second skin cicatrix. This procedure allows complete removal of the meniscus and is also useful for excision of cysts of the meniscus.

The use of the tourniquet is a controversial point. Many surgeons use it on every knee operation while others select certain types of injuries. There are many kinds and methods for its use. The pneumatic tourniquet can be easily released at any time prior to closure of the incision if the surgeon wishes to ligate the blood vessels. The Esmarch rubber bandage and the flat rubber tourniquet with a buckle that can be released are useful. In applying a tourniquet the limb should be elevated for a few minutes and an elastic bandage applied from the toes to the mid-thigh in order to "milk out" any remaining venous blood, before obtaining hemostasis with the tourniquet high on the thigh.

We are all familiar with the fact that each patient is an individual and must be treated as such. No two patients are the same. Therefore, we can use only averages when speaking of the number of days or weeks necessary for the different routine steps in the postoperative care of knees operated upon for excision of the meniscus or osteochondritis dissecans. The post-

operative treatment might follow this pattern:

1. Quadriceps setting exercises encouraged as soon as possible within the first few days. Instruction in these exercises should be given prior to operation. The extremity is elevated upon two pillows with the knee extended or in traction with Buck's extension.

2. Compression dressing is removed on the fifth or the sixth day. Incision inspected, cleansed, and sutures left in. Dry dressing with an elastic bandage applied extending from mid-leg to mid-thigh. Quadriceps exercises continued.

3. Sutures removed on the eighth day and leg raising extension exercises instituted.

4. On the ninth day the patient is encouraged to exercise over the edge of the bed by supporting the operative extremity with the non-operative extremity and flexing it until it becomes pianful. Physiotherapy is begun. Baking of the knee is good as both a psychological and therapeutic measure. The patient feels better and together with exercise definite improvement has been noted.

5. On the tenth day latrine privileges are given, the patient using crutches.

6. On the twelfth day reverse the exercises over the edge of the bed by flexing the operative knee with the non-operative extremity placed on the dorsum of the foot. The elastic bandage should be worn when out of bed. Physiotherapy is continued and exercise on the ward continued under direct supervision gradually replacing physiotherapy.

In the Army the soldier takes part, whenever possible before operation, in daily calisthenics which are given on the ward by trained personnel. Reconditioning exercises are started immediately post-operatively with special emphasis placed upon the development of the quadriceps muscle. The atrophy and disabling weakness which usually follows in arthrotomy of the knee joint has been lessened. The purpose of a program of reconditioning is

to return to duty soldiers who are recovering from injuries or disease in the best possible physical and mental condition. This can only be attained by a determined effort on the part of the reconditioning personnel and the patient. The Army has placed the patients into four classes: Class I are those patients almost fully reconditioned. Class II are those patients who are ambulatory but not on a full program. Class III are those patients who are convalescent and ambulatory still receiving treatment. Class IV are those patients considered convalescent but still confined to bed. The average hospitalization period before return to full duty in arthroscopy of the knee joint is three months. This differs from civilian practice in that the civilian patient convalesces at home. The soldier is reconditioned during his hospital stay. The number of days of hospitalization can be reduced and the soldier returned to duty in a better physical condition after he has participated in a well planned reconditioning program.

The importance of an active program of muscle development and reconditioning cannot be underestimated. Quadriceps muscle exercises in the preoperative and postoperative period is often neglected. Better results can be obtained in these knee conditions if an intensive and instructional program is instituted before surgery upon the knee, and this followed throughout the postoperative period until the patient is fully recovered. The efficient

and co-operative program which the Army has established making use of the physiotherapist, occupational therapist, reconditioning officer and surgeon is a big factor in the preoperative and postoperative care of the knee.

#### SUMMARY

1. The number of knee injuries seen in the Army among new recruits who have never had previous injury is high.
2. Traumatic synovitis of the knee is frequently mistreated. This condition often results in an arthritic knee joint.
3. Tears of the menisci and osteochondritis dissecans present a surgical problem which must be properly handled.
4. Quadriceps muscle exercises in the preoperative and postoperative period expedite recovery.
5. A co-operative program of reconditioning using the knowledge and experience of the physiotherapist, occupational therapist, reconditioning officer and surgeon is essential for good results.

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# COLLAPSE OF GLASS' EYES IN THE ORBIT

## CASE REPORT

WILLIAM M. HAYES, M.D.

On Visiting Staffs of Fort Hamilton and Mercy Hospitals

HAMILTON, OHIO

PREVIOUS to my first article,<sup>11</sup> on the "Collapse of Glass Eyes in the Orbit," the literature on the breaking of glass eyes in the orbit was under the title, "Explosion of Glass Eyes in the Orbit," with the exception of one reporting, that being under the title "Spontaneous Rupture of Glass Eye in Situ."

One has never beheld anyone in such a state of utter horror, excitement and bewilderment, until he has seen an individual who has had a glass eye let go in its orbit.

In thumbing over the literature covering the subject at hand, it is found to be very anemic, but to have come in contact with two cases in a five-year period in this immediate locale, one is led to the belief that the incidents are more prevalent than the cases finding their way into the literature.

No mention is made in any of the literature that I can find on safety rules in industries covering workmen wearing glass eyes being considered a hazard, nor is any reference made of it being covered by compensation laws in states which have such laws, in the event a workman receives any injury when a glass eye breaks while in the performance of his duties, when working near a blast furnace or the like.

The manufacturers of glass eyes, when being written to about the breaking of them while being worn, and being asked what caused them to break, and what could be done to prevent it, were very evasive in their answers, some of them not even replying to such inquiries. Several large optical appliance houses were interviewed about their breaking. They did not attempt to give any information or reason for the breaking but they knew that it occurred.

The companies that were interviewed do not make glass eyes but only handle them through the manufacturers. One of them informed me that he had artificial glass eyes break while on a tray in a display case, when they were exposed to the sun's rays on hot summer days for any length of time. The percentage was very small, but it did happen. It was always the posterior concave portion that gave way.

Rochester,<sup>1</sup> under the title "Spontaneous Explosion of Snellen Improved Artificial Eyes," does not report any individual cases but the breaking of artificial eyes in the orbit was called to his attention by a fellow colleague. Rochester had never heard or was he conscious of such a happening prior to this. He collected some cases and reviewed the literature. He interviewed some makers of artificial eyes and was told that the air-sealed cavity within the glass eye was less than one atmosphere. No sound reason was given why the breaking was called an explosion. He was told that some of the eyes broke while on the shelves, and that they broke on extremely hot or cold days; also that the makers of glass eyes were going to look into the cause of the breaking and they would like to do something to prevent the occurrence. He mentions that the orbital lining secretions through their chemical action had some effect on the glass eyes. This hardly goes hand in hand, as glass eyes break while on shelves. Rochester was so intrigued with the subject that he brought it up before the Chicago Ophthalmological Society, November 20, 1916.

It will be noted by the statement to Rochester by some makers of glass eyes that they were going to look into the cause of the breaking and that they would like to

do something to prevent the occurrence. This statement was made nearly thirty years ago, but evidently the makers of glass eyes have done nothing about it as they continue to break while in the orbit.

Metz<sup>2</sup> reports on the "Spontaneous Explosion of Artificial Eyes" and cites one case. A patient wearing a Snellen artificial eye reported that a few hours before, as he was crossing a vacant lot, he had been shot, the bullet striking his artificial eye (eye not mentioned). Although he could see no one about, yet he had heard the sharp report of a gun, and had felt the impact of the bullet on the eye. An attempt was then made to remove the eye from the orbit, and a little difficulty was experienced. Usually an artificial eye can be removed very easily, but for a reason not apparent the eye resisted removal. Finally, the attempt at removal succeeded, and it was observed that a slight hemorrhage was occurring from that portion of the conjunctiva which had been in contact with the central portion of the posterior wall of the eye.

Inspection of the eye revealed an irregular round opening about 5 mm. in diameter in the posterior central portion. A number of small fragments of glass were found within the interior of the eye. Quite apparently when the wall of the eye ruptured, the fragments were forced into the cavity and the conjunctiva was drawn into the eye by virtue of a vacuum which existed inside the glass globe. Retention of the conjunctiva in this hole in the eye explained the difficulty which had been experienced in removing the ball from the conjunctival sac, and also explained the slight injury to this portion of the conjunctiva.

At the time of the patient's visit the cause of the breaking of his eye was not clear. It could not be assumed that the eye had actually been struck by a bullet, and that without doing any damage whatever to the anterior portion, a gunshot should have occasioned so peculiar a fracture of the posterior wall. It was later that the

possibility of an explosion of the glass eye was considered.

Weilder<sup>3</sup> records one case under the title "Explosion of the Snellen Eye in the Orbit." He states that the explosion of the Snellen artificial glass eye while in the socket is a unique accident and seems to the writer (Weilder) to be worthy of record.

Also, the Snellen "reform" eye has so many well known advantages over the old style that it is needless to mention them at this time. The only disadvantage seems to be this tendency to explode.

The patient has been wearing Snellen reform eyes (left) which were made to order for the past ten years. The eye that exploded had been in use for only one year. The date of the breaking was August 1, 1916. She had been cooking over a hot stove and walked to the door where it was cool, when there was a peculiar noise in her head, which was followed by pain in the socket, and she thought she had been shot. She walked to her bedroom and fainted from fear and shock. When she recovered consciousness, she attempted to remove the glass eye and found it difficult to do so, on account of the great "suction" or vacuum. When the eye was removed a hole was found in the central part of the rear surface about 4 by 6 mm. in size. The piece that had broken out had fallen into the socket.

The patient said that the noise caused by the explosion was similar to the bursting of an electric light bulb.

Urbanek<sup>4</sup> presented a case of an explosion of an artificial eye in the right orbit, before the Vienna Ophthalmological Society, February 18, 1924, First Service of the Eye Clinic, his case being that of a woman fifty-three years of age. She had had tuberculosis of the right eye, and the eye was removed when she was seventeen years of age. A glass eye was put in. One morning in the early part of February, 1924, she stooped down and in doing so thought something had struck her in the region of the right temple. This was followed by pain in the right orbit, associated

with a flow of tears, and the tears were bloody. In vain she had sought to remove the artificial eye. She was brought to the clinic shortly after in the ambulance. While in the clinic she was seen by Professor Meller, and he pointed out to us the possibility of a spontaneous explosion of an artificial eye within the orbit. He separated the lids and he had much difficulty in removing the artificial eye. The back portion of the eye was found to have a piece broken out of it. The opening measured 10 mm. long and 5 mm. wide.

Urbanek, in presenting this case, also referred to Kayser, of Stuttgart, who had a similar case in 1918 of an explosion of an artificial eye in the orbit. Difficulty was had in removing the eye, and Kayser mentioned the importance of having a lever made to remove any eye in the future. Urbanek, in the case he reports, does not make any reference to the piece that was broken out in the back of the glass eye; that is, if he looked for it, and if located what was the location. He does not state how long the eye had been in use, or whether the eye showed any erosions. In fact, he makes no mention of the secretions of the orbit.

Lewis<sup>5</sup> cites one case of "Explosion" of Artificial Eye in the Orbit, and I quote him verbatim:

"Whether the 'Explosion' was due to positive or negative air pressure within the glass eye, or from pressure of the surrounding orbital tissues upon it, cannot be determined. But removal of the eye (eye not mentioned) from the orbit, afterward, was accomplished with difficulty, on account of suction within, which held a tuft of the conjunctival tissue fast in the aperture in the glass, and necessitated considerable force to pull it loose.

"The patient is a mechanic of superior intelligence and his description of the occurrence is most interesting. Sitting in the power station, while on duty, he was reading when an explosive-like shock took place in the orbit. Fellow workers, who were looking directly at him at the moment,

state that his head jerked violently backward.

"He immediately felt pain in the orbit and upon attempting to remove the artificial eye, which he could, ordinarily, do with ease, he found that something held it fast (suction), and it had to be wedged out with considerable force. The conjunctiva over the stump was found to be bleeding and slightly lacerated. Close examination of the glass eye showed an aperture in its posterior, concave surface, about 5 mm. in diameter. The broken glass pieces were contained within the eye and slightly blood stained.

"The glass eye was entirely smooth, showed no erosion, as is commonly found after long use, nor is it perceptibly different from the usual prosthesis. The patient had worn a glass eye for many years and this particular one about six or seven months. It was an exceptional experience to both patient and surgeon."

McKee<sup>6</sup> cites three cases but does not attempt to give any cause for their breaking. His recordings are under the heading of "Explosion of Artificial Eyes in the Orbit."

His report is as follows, and I quote him in full: "Dr. W. W. Lewis' report in the December number of the Journal, page 923, (American Journal of Ophthalmology—Vol. 10, page 923-924, December, 1927), prompts me to record a small series of such cases which I have intended reporting for some time. They all occurred in 1923 and January, 1924.

"M. McF., an adult male, while at his work, had the glass eye on the right side explode. The artificial eye was completely demolished and when I saw him within an hour or two of the accident he was in quite a state of shock. I removed innumerable small pieces of glass from the socket.

"G. S., a young woman of twenty-two years, within a few months during 1923 had three glass eyes explode in her orbit (eye not mentioned). This patient had been most particular about her artificial eyes and had gone to most of the large American

cities in search of the best that could be procured.

"In January, 1924, A. M., an adult male of twenty-eight years, came to have his eye socket inspected, (eye not mentioned) as the day before an artificial eye had exploded in the orbit. He said "he felt as if his brains were being knocked out," and when I saw him he was still in a very nervous state."

Dunphy<sup>7</sup> reports one case of "Explosion of Artificial Eye in the Orbit" as follows: "Since reading the case report of Dr. Wm. W. Lewis in the December issue of the Journal (American Journal of Ophthalmology—Vol. 10, page 923-924, December, 1927), I have seen a similar case of 'exploding' glass eye.

"The patient, a young man of twenty years, was sitting quietly on a screened-in-porch, reading a book. Suddenly a loud report was heard as if a pane of glass had broken, and the patient felt as if he had been struck on the head. His parents, who were present at the time, confirmed the story. Immediately he had a severe pain in his eye socket (eye not mentioned) and found it was impossible to remove the glass eye. I removed it with some difficulty and found over the stump a lacerated conjunctiva which bled considerably. The glass eye showed an irregularly broken posterior surface.

"The broken glass was recovered from within the eye. The prosthesis had been made by a reputable firm and had been worn four months."

Collado<sup>8</sup> reports a very interesting case, and goes much into detail. He was called to see a woman forty-one years of age. She had lost the sight of the left eye when six years of age, due to an accident. The eye was removed. She had been wearing glass eyes for the past fifteen years. One glass eye had been in use for eight years without its removal from the socket. The eye that ruptured had been in constant use for two years without ever being removed. Collado does not state why the eyes were worn constantly and not removed for cleansing.

This woman, he remarks, had a malignancy of the uterus and is receiving radium treatments. She was about her regular house work when she felt what she thought was an explosion in the glass eye. The patient, when visited, was in a semi-conscious state and in severe pain. Cocain solution (strength not given) was dropped around the glass eye to find its way to the soft parts, and then he attempted its removal. The patient complained of great pain. Novocain solution 2 per cent was injected into the surrounding parts. The eye was firm in the socket and could not be budged and more solution was injected. In all, three hours were spent in removing the eye. Finally, a glass rod was used as a lever and the eye was pried out. All this was associated with great pain. It was noted that the eye was being held back in the eye socket as if some force was holding it. After removing the eye there was much hemorrhage. The glass eye was washed and it was found that a piece was broken out in the back of the eye and that the broken piece was found within the cavity of the glass eye. He was of the opinion that a metastatic process had taken place in the soft tissues in the back of the orbit and the tumor mass pressing on the back portion of the eye had broken it in, and the cause of the anchorage of the glass eye in the socket was due to the tumor mass forced into the hole in the back portion of the eye where the piece had broken out. He makes mention that he did not explore to see if there was a tumor mass in the orbit. He considered this a curious and rare case, and that perhaps no one else had experienced a similar case, and thought that he should publish it. He showed two photographs of the broken glass eye, one where the piece had broken out of the posterior surface. In reporting his case he does not make any mention if the eye showed any erosions or roughness from the secretions. This is an important point, as the eye had been worn constantly for two years without its removal.

Walker<sup>9</sup> published a case under the title "Artificial Eye Removed with Laryngeal Mirror" as follows: "About six o'clock on the evening of July 28, 1935, a young man, aged twenty, came running into my home, crying with pain and stating that his artificial eye had 'exploded' a few minutes previously. The day had been hot, with the temperature 101°F. throughout most of the afternoon. At 4:30 o'clock, the boy had gone into a swimming pool for an hour. As he was riding homeward in an automobile, he had heard and felt a cracking sensation in his artificial right eye. A severe cutting pain in the orbit immediately ensued, and he was unable to remove the eye. He had worn an artificial eye for six years, after enucleation following an injury. He had been wearing the eye, which caused his present complaint for eight months. He had had no similar trouble previously.

"The artificial eye seemed to be adherent to the conjunctiva lining the orbit. Manipulation in an attempt to remove it caused exaggeration of his pain. By pressure on the lateral surface of the eye, the inner edge could be seen, but could not be grasped with the fingers so as to exert strong traction. Hurriedly surveying my armamentarium for something to slip behind the artificial eye to aid in its removal, a small laryngeal mirror seemed suitable. I introduced this instrument at the lower inner edge of the eye, freed the conjunctiva from the posterior surface, and the eye was then easily removed.

"In the center of the posterior surface of the eye was an irregular jagged opening eight mm. in diameter. The fragments of glass had fallen into the cavity of the artificial eye, allowing folds of conjunctiva to be caught by the sharp edges of the broken glass. The conjunctiva was abraded and superficially lacerated at the site of its incarceration, but healed rapidly."

What is the cause of explosion of artificial eyes while being worn?<sup>10</sup> The answer is quoted in full: "From time to time there appears in the literature the account of an explosion of an artificial eye without

apparent cause, while being worn. All in all, less than a dozen incidents have been reported. It is believed such explosions result from the sudden admission of air to the interior of the eye. In the process of manufacture, the air within the shell of the prosthesis is expelled by the heat to which the glass is subject while being formed. Ordinarily, the vacuum thus produced is maintained, but in some persons there is enough secretion from the socket to cause a gradual erosion of the shell. The erosion may hit a thin spot in the shell, and, when the external air pressure is greater than the strength and resistance of the glass at this area, the wall of the shell is forcibly ruptured. Usually there is no explosion, but under certain conditions that are not fully understood the sudden advent of the air under ordinary atmospheric pressure is sufficient to cause the explosion."

Hayes<sup>11</sup> reports one case under the title, "Collapse of Glass Eyes in the Orbit": "C. A. W. White male. Age 36. General health very good. The left eye was enucleated January 18, 1937, due to an injury. He started to use an artificial eye about the middle of March, 1937. The eye had been in use only for two months. The eye was removed frequently for cleansing. May 17, 1937, he came from a cool place and sat out in the sun to lunch (noon-time). He was sitting in the sun without a hat for about 15 minutes. He stated that he felt as if something had struck him in the artificial eye with great force, and a marked report was made that sounded to him like an explosion. He placed his hand over his eye and discovered that he had a small amount of blood on his finger-tips. He tried to remove the glass eye and it felt as if something was holding it back, like a suction in the back portion of the glass eye. During this time he suffered great pain. Finally he removed the eye, which was followed by a large amount of blood running down his face. When the eye broke he felt dazed for a few moments. I saw him about 10 minutes after the breaking of the eye. He was rather unsteady and insisted that some-

thing had struck him in the artificial eye. At this time there was considerable hemorrhage. He was placed upon a cot and finally the bleeding stopped and he regained his poise. The artificial eye was examined and a small piece was found to have broken out in the back portion of the eye, the aperture measuring a quarter of an inch in length (6 mm.) and an eighth of an inch in width (3 mm.). The socket of the eye was examined for the piece that had broken out, but it could not be found. The artificial eye was washed and cleansed, and the broken piece was then found within the cavity of the glass eye. The eye was smooth and showed no erosions. Since the breaking of this eye he has worn another, removing it only for cleansing."

Gresham,<sup>12</sup> of Russellville, Alabama, under date of December 23, 1938, wrote me after reading my article in Industrial Medicine on "Collapse of Glass Eyes in the Orbit" as follows: "A few weeks ago a negro man about forty called at about one o'clock in the morning. He reported to me that while he was sleeping an explosion occurred which frightened him, and with much pain he found that his glass eye had exploded. There was very slight hemorrhage and no damage to his orbit."

Behrman<sup>13</sup> reports under the title, "A Rare Accident to the Eye" (Non-industrial), as follows: "On April 3, 1938, Mr. G. B., while washing his face heard an explosion in his head and collapsed. When first seen the patient was sitting in a chair, utterly collapsed, holding his hand over his eye. (Eye not mentioned).

"Examination showed the glass eye to be shattered but no serious damage had apparently resulted to the surrounding tissues."

Dr. Behrman states that he took the matter up with Max Wocher Co., of Cincinnati, Ohio, a large distributor of glass eyes, and was informed that this accident is really due to a flaw in the glass; that when heat is applied the hollow glass in expanding in a rigid cavity, "explodes."

The patient informed Dr. Behrman

that he had a friend who was seriously injured in a similar way.

Dr. Behrman does not state that his patient was washing his face in hot water at the time of the breaking of his glass eye, but we can take for granted that he was.

#### CASE REPORT

G. E. T., a white male, age fifty-four, whose general health was very good, injured his right eye eighteen years ago which resulted in its being enucleated and since that time he has been wearing a glass eye. He changes over to a new glass eye every two and one-half years, gives no reason for doing so, but just likes to make the change. He has been purchasing his glass eyes from the same surgical supply house since using them. He removes the eye about every seven days and cleanses it thoroughly. On January 20, 1944, at about 6:45 A.M., while sleeping in a room which was at 45° F., he was awakened suddenly by a terrific noise, which sounded as if an explosion had taken place and he thought that some one had fired through the window and shot him in his right eye. He stated that he was stunned and grasped his head between his hands and thought that the top of his head had been blown off. He finally moved one hand to the top of his head to see if it was all there. Later, he placed the palm of one of his hands over his glass eye. By this time his wife had turned on the light and he saw a small amount of blood in his palm when he removed his hand from over his eye. During this time he was "off balance," as he describes it, and took about five minutes to locate himself. During this time he was suffering untold pain in his right orbit where the glass eye was still in place. He tried vainly to take the eye from its socket but in this he failed. The glass eye seemed as if it was anchored in the eye socket. He described as feeling as if something was being sucked into his glass eye and the pain was unbearable. Only a few drops of blood came from the eye socket.

He was taken to the Mercy Hospital, Hamilton, Ohio, and admitted to the emergency room. He was given morphine sulfate gr.  $\frac{1}{4}$  (.016 Gm.) by needle. He was now relieved of all anxiety.

The glass eye was removed by Dr. Malcolm Bronson, ophthalmologist. Six drops of ponto-

caine hydrochloride 2 per cent was instilled into the orbit around the glass eye. Two small levers were placed under the glass eye, one to

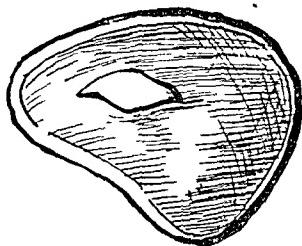


FIG. 1. Glass eye showing the aperture in its posterior concave portion where the piece is broken out.

the outer and the other to the inner side and the glass eye was lifted out of the orbit. It came out rather easily. A moderate amount of hemorrhage followed its removal.

The glass eye (Fig. 1) was thoroughly cleansed and found to be smooth and showed no erosions. A piece was broken out in its posterior concave portion and found within the cavity of the eye. The aperture measured one-half inch in length (12 mm.) which ran across the long axis of the eye and a quarter-inch in width (6 mm.) across its short axis. The piece that was broken out was measured for thickness with a micrometer and found to be  $\frac{1}{45}$  of an inch (.5 mm.).

At the present time the patient is none the worse for his experience and is wearing another glass eye.

The writer believes that the cause of the breaking of artificial eyes should be cleared up, either while being worn or on the shelves and whether the eye explodes or collapses. If the eye breaks, there would be a report similar to an explosion; is this report due to the eye exploding or collapsing? This would depend upon the pressure within the cavity of the glass eye. The glass eye being in the socket and surrounded by a bone wall, when breaking one can appreciate the recording on the auditory apparatus; whether it is an explosion or collapse you have the same recording.

A comparison will be made between incandescent lamp bulbs and glass eyes when being broken and the report that is

recorded when they are broken and the cause of the report; whether the lamp bulb or the glass eye be hot or cold.

If two types of incandescent lamp bulbs, that is, where one bulb is well under one atmospheric pressure (one atmosphere—15 pounds) at or near a vacuum and the other bulb being well over one atmosphere (25 pounds) the bulbs being hot or cold, when broken by casting them against some object, a marked report will be recorded as if an explosion had taken place. With the bulb that is well under one atmosphere (at or near a vacuum) when broken, the report that is recorded as if an explosion had taken place is due to the outside air rushing in, which is at one atmosphere, equalizing the inside and the outside pressure. In the case of the second bulb that is well over one atmosphere when being broken, the report that is recorded as if an explosion had taken place, is due to the air rushing out of the bulb to equalize the outside pressure—one atmosphere.

If a third type of incandescent lamp bulb is used where it is at one atmosphere and when being broken against some object, the only report recorded is the breaking of the glass. No report is made as if an explosion had taken place. This is due to the atmospheric pressure being equal, that is, the same pressure inside and outside of the bulb. The same would be true for glass eyes in the orbit when broken for sound recording.

Four glass eyes in good condition, some broken glass eyes, and one glass eye that was broken while being worn, were obtained from an optical appliance company. The eye that was broken while being worn was broken in the posterior concave portion and the piece that was broken out was within the cavity of the glass eye. All of this material was sent to a very responsible laboratory so that the construction of glass eyes could be seen. A special request was made for the pressures within the four glass eyes sent. The laboratory reported as follows: Two of the four eyes were examined for internal pressures. One had

one-half and the other had one-third of an atmosphere.

The optical company from whom this material was obtained explained that the eyes were made and blown at a white heat. A glass eye about 80 per cent complete (Fig. 2) shows the globular mass with its long stem four inches in length. The stem has a capillary opening in it leading from the cavity of the globe to the outside air.

The bulb portion where the stem is attached is heated to such a degree that it is made pliable, so that when the stem is pushed forward toward the bulb the concave posterior portion of the eye is formed. During this maneuver the air that was within the bulb when it was cold was at one atmosphere. When the bulb was heated the contained air expanded and a portion of it made its exit to the outside air by way of the capillary in the stem. The eye is now completed by twisting off the stem, which now seals the eye. When the glass eye cools off at body temperature, the air that remains in the cavity of the eye contracts and the pressure within the cavity is equal to about one-half or one-third of an atmosphere. This was proved by the laboratory that examined two of four glass eyes sent them for test for internal pressure.

If a transverse cross-section is made through the mid-point of an artificial eye it will be seen that about 70 per cent of the material is in the anterior half and the other 30 per cent is in the posterior half. The anterior half needs protection, hence about 70 per cent of the material is in this portion of the eye. The posterior half is frail and thin, and being concealed well back in the socket needs no protection. It would seem that where the stem is twisted off at the time of closure would be the weak point. All the eyes that break do so in the posterior half of the concave portion, whether in the orbit or on the shelves. Only a very small percentage break, but there should be some way even to prevent this small percentage.

In the case herein reported, my previous

case report,<sup>11</sup> and the collected cases, it will be noted that the posterior concave portion of the glass eye is the part that is



FIG. 2. Glass eye 80 per cent complete, showing the formation of the bulb with the stem attached. There is a capillary in the stem leading into the hollow bulb.

always broken. Trouble is encountered in removing the eye due to the soft parts of the orbit being sucked into the cavity of the glass eye by way of the aperture corresponding to the part that has given away. The hemorrhage is slight as long as the soft parts are engaged within the cavity of the eye by way of the aperture, also the pain is more severe. When the eye is removed the hemorrhage is more profuse and the pain markedly subsides. The piece that is broken out is found within the cavity of the glass eye after its removal.

Where the greater part of the posterior concave portion of the glass eye is shattered there is no difficulty in removing the eye as the soft parts of the orbit are not drawn into its cavity. The hemorrhage is

just as marked at the time of the breaking as when the eye is removed. The shattered parts of the glass eye are found adhered to the soft parts of the orbit after the eye is removed, and not found within its cavity.

Since the manufacturers of artificial glass eyes would not give any information as to their fabrication, one of the outstanding manufacturers of incandescent lamps was written to and asked if they could throw some light on the manufacture of glass eyes and why they broke, also what remedy or remedies could be offered to prevent the breaking.

The executive engineer replied that I had proved quite definitely that the failure of the glass eye is a collapse and not an explosion. He stated that they were not familiar with the process of fabricating glass eyes, but assumed that the closure is made with the glass close to its melting point and with atmospheric pressure inside. If this is the case, it is to be expected that the eye at body temperature would have an internal pressure of only about one-third of an atmosphere.

In his letter he stated that the following three remedies suggested themselves:

One would be to fill the internal cavity, when the glass is hot, at an absolute pressure of two atmospheres, that is, one atmosphere higher than outside pressure. This would mean at body temperature the internal pressure would be approximately one atmosphere, so that internal and outside pressures would be balanced.

The second measure, which perhaps is already employed, and which certainly should be if it is not, is to examine each eye carefully with a polariscope to detect strains and to reject all eyes which show strain.

The third measure would be to use stronger glass, if possible, than is used at present. We do not know what glass is now used, but some glasses, such as the borosilicate glasses, of which pyrex is an example, are mechanically much stronger than the ordinary lead or lime glasses.

The writer offers the following for test-

ing out glass eyes for their weakness or frailness:

Place the glass eye in a container which can be brought up to a temperature of  $130^{\circ}\text{F}$ . and then have the eye sustain a pressure of three atmospheres (45 pounds) for a period of fifteen minutes.

The cause of the eye breaking is not due to its exploding but its collapsing. The great majority of glass eyes break during hot weather, while people wearing them are working in places of extreme heat or coming suddenly from a place that is cold to one of warmth. The heat causes the glass eye to expand and become ironed out, especially the posterior concave portion which is thin and frail; the frailest part would seem to be where the stem is twisted off to make the closure of the eye. The pressure might rise slightly within the eye above the one-third or one-half of an atmosphere. (Probably the eyes that break are the ones that are near the vacuum point.) The pressure around the glass eye is one atmosphere. Here you have a greater pressure on the outside of the glass eye than within the cavity of the eye. The concave posterior portion being the weakest and unable to withstand the outside pressure collapses and does not explode.

The glass eye also breaks in cool weather as in the case herein reported ( $45^{\circ}\text{F}$ .). The orbital secretions evidently played no part in weakening the eye as it was smooth throughout and showed no points of erosions.

To prove that the eye collapses, the soft orbital tissue parts are sucked into the aperture where the piece is broken out. The smaller the aperture, the more firmly is anchored the soft part that is sucked into the cavity of the eye and this is proved by the extreme difficulty in removing the glass eye from its orbit. On examining the eye for the piece that has been broken out, this piece is found within the cavity of the glass eye, which proves that the eye collapses and does not explode. The only exception to the piece not being found within the cavity of the eye, is where the glass eye

is entirely shattered in its posterior concave portion when it collapses, and upon the removal of the eye which is very easy as it is not anchored, the broken pieces adhere to the soft parts of the orbit.

When the eye collapses there is a rushing in of air and the sound that is transmitted to the auditory apparatus sounds as if an explosion has taken place.

It is very unfortunate that all of the case reports do not give the conditions under which the eyes break. The eyes that break are frail to begin with and cannot withstand the external pressure of one atmosphere. It is very fortunate indeed that only a very small percentage of glass eyes break. From the literature, not very much stress is placed on the secretions from the orbital tissues eroding the glass eye and causing this to weaken the eye and preparing it to break.

Lewis<sup>5</sup> observed that the eye was smooth and showed no roughness.

McKee<sup>6</sup> in his case No. 2, had three eyes to break within three months.

Collado<sup>8</sup> makes no mention of the eye being rough, although it was in constant use for two years and not even removed from the socket for cleansing.

The writer's two cases showed no roughness of the glass eyes. They were smooth throughout just as if they had not been in use.

All the eyes referred to above that broke while in the orbit had not been in use for a long period of time, not over one year, the only exception being Collado's case.

#### SUMMARY AND CONCLUSIONS

The glass eye collapses and does not explode, whether hot or cold. The report made that the individual hears, and considers an explosion, is an inrush of air within the cavity of the eye when breaking. The external pressure (one atmosphere) is greater than the internal pressure (near a

vacuum) causing the eye to collapse in its concave posterior portion which is the weakest point. The eye is removed from the orbit with difficulty due to the soft parts of the orbit being sucked into the cavity of the eye by way of the aperture where the piece has broken out. The smaller the aperture, the more firmly the eye is anchored and the more difficult to remove. The piece that is broken out is always found within the cavity of the eye, proving that the eye collapses.

Where the posterior concave portion of the eye is shattered at the time of the collapse, there is no difficulty in removing the eye, as the soft parts of the orbit are not anchored and the eye can be lifted right out of the orbit, also the shattered pieces adhere to the soft parts of the orbit and the piece or pieces are not found within the cavity of the glass eye.

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# DISLOCATIONS OF THE SHOULDER

LT. COL. LEONARD F. BUSH

MEDICAL CORPS, ARMY OF THE UNITED STATES

THE frequent occurrence of dislocations of the shoulder makes this subject of interest to the general practitioner and surgeon alike. Acute or initial dislocations of the shoulder are common, and require not only early, non-traumatic reduction, but adequate post-reduction treatment to prevent the recurring or chronically dislocating joint. Patients suffering from recurrent dislocations of the shoulder develop a definite fear or anxiety complex, which can be relieved only by correction of the condition. With these thoughts in mind, the purpose of this article is to present a simple method of reduction of dislocations, and a corrective operation for the chronic dislocating shoulder, which have proved successful.

When the shoulder dislocates, there is not only a laceration of the joint capsule, but a stretching or sprain of the biceps tendon and its surrounding tendon sheath. At operation on recurrently dislocating shoulders, it has been noticed that there is old blood along the tendon sheath, a shallow bicipital groove and a looseness of the transverse humeral fascia and tendon sheath at the anatomical neck of the humerus. The old blood has been found several days after recent dislocations, indicating severe trauma at that point.

X-ray examinations should be made of all acute dislocations of the shoulder to rule out an accompanying fracture. Thorough x-ray studies should also be made before operative procedures are undertaken. When the lower border of the glenoid fossa has been fractured leaving a shallow cup for the head of the humerus, contemplated suspension operations, such as that of Nicola,<sup>5</sup> will be less successful. In such instances, the operation devised by Speed<sup>6</sup> would seem most efficacious.

In recurrent dislocations in which the shoulder slips out of joint without trauma, x-ray examinations are not necessary prior to reduction.

In recurrent dislocations of the shoulder following the Nicola procedure, one should suspect a complete atrophy of the tendon or separation of the suture site. The atrophy which has been found may be explained by the fact that the nutritive supply which comes from the muscle belly of the biceps has been severed at operation and has not regenerated. In such cases the operation devised by Henderson<sup>2</sup> should be considered.

*Acute dislocations*, or those occurring for the first time, are reduced and treated by a body bandage and supporting sling for three weeks before motion is started. After this period of immobilization, graduated exercises are started until normal activity is reached in six or eight weeks. We have had no recurrences in patients treated in this manner. This is perhaps a coincidence, but it is believed that proper immobilization, followed by gradual use, will allow the torn capsule and tendon sheath to heal.

## REDUCTION OF DISLOCATIONS

Acute or recurrent dislocations are easily reduced without trauma in the following manner. X-rays are taken as indicated. One-fourth gr. of morphine is given, either by the subcutaneous or intravenous route. With the patient lying supine, an assistant applies firm traction on the opposite arm, or the same force may be obtained by placing a sheet around the thorax. Gentle, constant and increasing traction is applied on the involved arm, with the elbow flexed at a right angle, the forearm being held in a vertical position. The patient is reassured and asked to breathe

deeply and relax the shoulder muscles. While constant traction is maintained, the flexed arm is gently rotated toward the

particular care being taken to preserve the anterior branches of the circumflex humeral nerve. (Fig. 2.) This precaution prevents

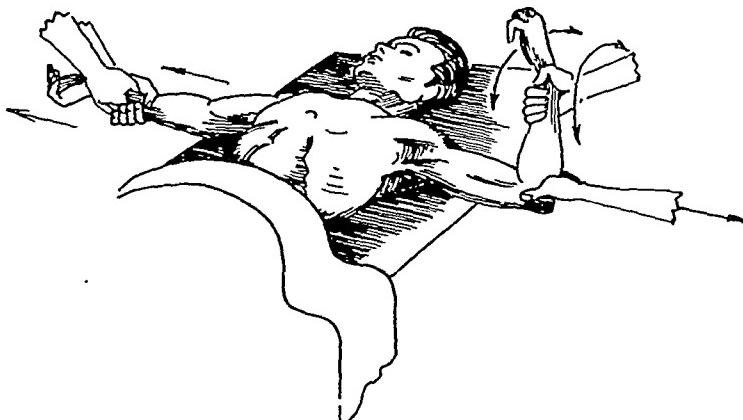


FIG. 1. Illustrates the position of the patient and the direction of forces exerted for the reduction of dislocated shoulders.

head as shown in Figure 1. The head of the humerus then slides into the joint with ease.

This method has been entirely successful in all anterior, posterior and inferior or subglenoid dislocations, and is not as traumatizing as some of the methods and maneuvers which have been advocated. This same procedure may be used with a general anesthetic, although anesthesia has not been found necessary in a successive number of either acute or chronic dislocations of the shoulder.

#### MODIFICATION OF THE NICOLA OPERATION FOR RECURRENT DISLOCATING SHOULDERS

The operative technic which is to be described has been suggested by Capt. H. W. Grosselfinger, who was associated with the Orthopedic Department at Strong Memorial Hospital prior to his entry into the armed forces. We have used this procedure, with some modifications, on twenty patients. Roberts<sup>7</sup> has described a somewhat similar procedure.

*Operative Technic.* A four inch incision is made from a point just anterior to the acromion process, extending distally to the lower end of the deltoid muscle. The deltoid muscle fibers are separated posterior to the path of the cephalic vein,

postoperative atrophy of the anterior portion of the deltoid muscle, although it makes the operation slightly more difficult. By rotating the arm, the bicipital groove is easily palpated and the transverse humerus ligament and the synovial sheath surrounding the long head of the biceps (bicipital tendon) are opened. The entire tendon sheath is incised along the course of the tendon, including part of the joint capsule of the shoulder. Considerable bleeding can be eliminated at this point if the circumflex humerus vessels are isolated and ligated. The tendon is then removed from the groove and retracted by a cotton tape. (Fig. 3.) By means of osteotomes and chisels, a new channel is created from a point on the head of the humerus one-half inch above the anatomical neck to the point of exit of the bicipital tendon from its sheath. (Fig. 4.) By forcing two osteotomes laterally, in opposite directions to each other, along the entire groove, a new channel approximately one-half inch deep is made in the cancellous portion of the humerus. The tape is removed, and the tendon is placed into its new groove, one-half inch in depth in the upper shaft and head of the humerus. The contraction of the muscle will hold the tendon in place, but a tension suture is placed through the

tendon and fascia at its exit from the channel to keep it taut. The joint capsule is usually redundant or excessively loose

in two layers, the deltoid fascia and the skin, by means of interrupted cotton sutures.

FIG. 2.

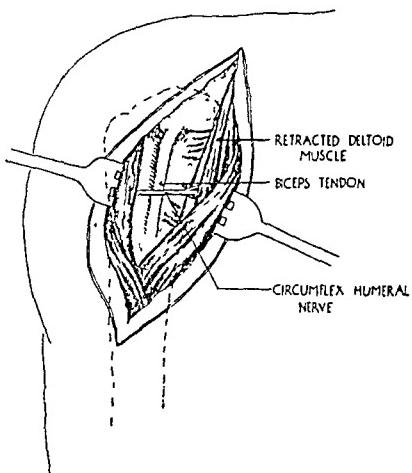


FIG. 3.

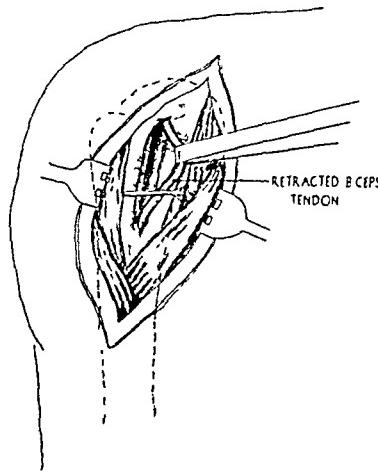


FIG. 4.

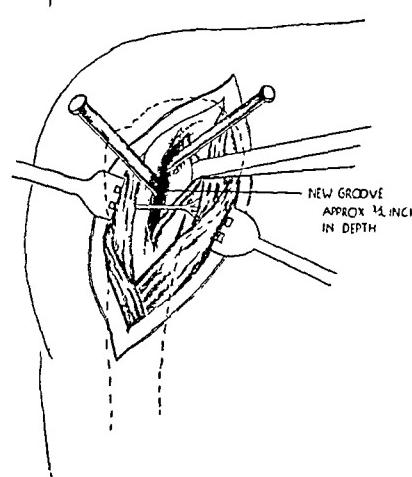


FIG. 5.

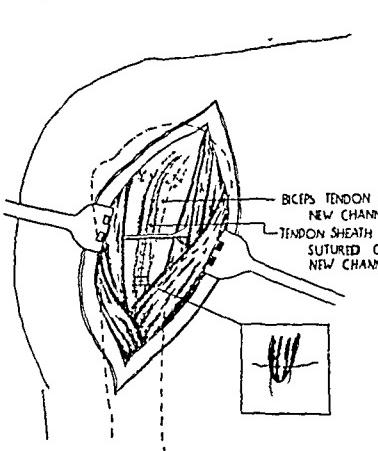


FIG. 2. The type of incision and the structures encountered, showing preservation of the circumflex humeral nerve.

FIG. 3. The tendon sheath of the biceps tendon has been incised and the tendon retracted. The joint capsule of the shoulder has been opened for a short distance.

FIG. 4. The osteotomes are shown in the new groove at the site of the bicipital depression, which should extend into the head of the humerus at least one-half inch.

FIG. 5. The transverse humerus fascia and tendon sheath are shown sutured over the new channel. Insert shows tightening suture.

along the anterior portion. Added security is obtained by freezing the joint capsule along the anterior border of the neck of the humerus and plicating it by suturing the anterior cut edge to the lateral border of the bicipital groove. (Insert Fig. 5.) The transverse humerus ligament, synovial sheath and periosteum are then sutured as one over the top of the tendon in its new channel. (Fig. 5.) The wound is then closed

#### POSTOPERATIVE CARE

The arm is supported by a Velpeau-type dressing, care being taken to separate opposing skin surfaces by padding. New dressings are applied weekly, and the sutures are removed on the seventh to the ninth day. After three weeks all dressings are removed, the arm is placed in a sling, and early motion is started. At four weeks,

the sling is discarded, increasing motion and physiotherapy are begun. At the end of five weeks, the patient is able to move the arm in all directions, including complete abduction and extension above the head. The only limitation after six weeks is placing the hand in the hip pocket. After adequate exercise, normal use can be expected in eight weeks. Excessive exercises are discouraged until a three-month period has elapsed.

There have been no recurrences in our series. All patients have been followed for several weeks after returning to active duty, where they have done exercises and work which had caused their previous dislocations. Two patients have been examined well over a year following their operation. Both are doing strenuous army work and their shoulders were functioning normally. One of these men was quite neurotic and apprehensive prior to operation, but has improved and developed into a useful soldier. There have been no complications resulting from the operation. One patient has been detached from the service because of neuropsychiatric reasons.

The advantages of this operation are: It is technically simple; it preserves the

blood and nerve supply to the biceps tendon; it gives early and normal function and a new feeling of support and security to the previously afflicted patient.

#### CONCLUSION

A method for the reduction of uncomplicated dislocated shoulders, and an operation for the correction of recurrent dislocations have been presented.

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# LOCAL TREATMENT OF BURNS WITH PRESSURE DRESSINGS AND FILMS CONTAINING SULFONAMIDE\*

MAJOR EVAN C. REESE  
MEDICAL CORPS, ARMY OF THE UNITED STATES

To date numerous methods of burn therapy have been reported. In fact, according to Harkins,<sup>1</sup> Whipple,<sup>2</sup> and McClure and Lam,<sup>3</sup> fifty to eighty-four different therapeutic methods have been used. In a recent treatise Whipple<sup>2</sup> questions the value of conclusions concerning the treatment of first and second degree burns by any of the commonly used methods. He believes that equally good results can be obtained with all of them. However, Maun and co-workers<sup>4</sup> and Hirshfeld and co-workers<sup>5</sup> are of the opinion that a number of commonly accepted regimes have caused delay in the healing of first and second degree burns because of their destructive effect on remaining layers of epithelium. This results not infrequently in the partial conversion of a second degree burn into one of third degree, perhaps with scar formation and even contracture.

With burns representing one of the major surgical problems among the casualties of this war, many new forms of treatment have been proposed, some of them making use of the various new chemotherapeutic agents, especially the sulfonamides. The use of various films as "preformed eschars" has attracted wide attention.<sup>6,7,8</sup> For example Whipple<sup>2</sup> states, "Films of several kinds, . . . when used with an understanding and appreciation of the basic principles of burn therapy, will undoubtedly prove valuable."

In this paper we wish to report on the results obtained in forty-three cases of burns of various types, which were treated

with transparent films containing sulfonamides and by using pressure dressing on top of the film. In view of the limited clinical material available in our hospital we could not attempt a comparative evaluation of this method and merely wished to obtain additional evidence regarding the possible merits of the treatment described by Andrus et al.<sup>6</sup>

Stimulated by the late F. C. Schmelkes, work in our hospital was started about two years ago by Captain F. L. Knotts. A series of patients treated by him will be the subject of a separate report. At that time the value of local application of sulfonamides was being widely studied, the work of Meleney and others<sup>9,10</sup> disproving its merits had not yet been published, and the use of vaseline gauze pressure dressing had not been officially adopted.

## METHOD OF TREATMENT

The film used in these cases was .004 inches thick. It was transparent, pliable, and conformed easily to body surfaces. The base of the film was methylcellulose to which was added triethanolamine in addition to a plasticizer. Although slight variations in the sulfonamide content were made in a few instances, the standard film employed contained 20 per cent sulfanilamide and 10 per cent sulfacetamide. It was estimated that 1 sq. cm. of the film contains 3 mg. of the sulfonamide. Recently  $\frac{1}{2}$  per cent proflavine has been added to the film content. Triethanolamine was used in this film because it maintains

\*The material used in this series was obtained through the courtesy of Wallace and Tiernan Products, Inc., Belleville, New Jersey.

the hydrogen ion concentration of the surrounding medium at a slightly alkaline reaction (pH 8.5) which enhances the effectiveness of sulfanilamide.<sup>11,12</sup>

In accordance with the principle that burns should be considered as open wounds and treated with the utmost aseptic precaution, the following method was adopted:

1. In an attempt to control shock, either present or impending, every effort was made to make the patient comfortable by the administration of adequate doses of morphine, and by the removal of tight and heavy clothing. Plasma was given as indicated by the extent of the burn, the general symptoms, and the hematocrit value.

2. The operator scrubbed for ten minutes and wore a mask, as well as a sterile gown and gloves.

3. For the sake of evaluation of the antibacterial efficiency of the particular treatment used, a sample of the exudate was taken by means of a cotton swab and sent to the laboratory for culture.

4. The burned area was carefully cleansed with neutral soap and water for ten minutes. Pledgets of cotton were used so as not to injure the remaining epithelium. After cleansing, the area was irrigated with warm saline. All devitalized tissue was removed and large blebs excised. If the burned area was grossly contaminated, it was painted with a solution of azochloramid in triacetin (1:500).

5. Sufficient film to cover the burned area and a portion of the surrounding normal skin was then applied. If the area was exceedingly moist, a double thickness was used.

6. Gauze or cotton dressings were firmly placed over the film to act as a pressure dressing. The area was then bandaged, preferably with an elastic type bandage.

7. The superficial dressing (not the film) was removed on the fourth or fifth day for inspection of the burn through the transparent film to determine the extent of healing. For the purpose of this investigation such inspections were made

as frequently as desired but the film was not removed until healing was complete. A second dressing was made a few days later unless excessive moisture, drainage, or evidence of infection necessitated earlier observation. If an area of maceration was found, a culture was taken and new film was placed over the macerated area. No attempt was made to remove the intact film at this time.

8. The film was found to peel off spontaneously after the burn had been completely epithelialized, although sponging with saline or water was used occasionally to facilitate the removal.

A summary of the case histories is given in Table I.

## RESULTS

In thirty-nine cases the burns were second degree; in four cases second and third degree burns were present. Of the thirty-nine second degree burns, thirty-four were treated by cleansing with neutral soap and water, débridement, and application without cleansing or débridement.

The thirty-four débrided second degree burns were completely healed within four to twelve days after film application. This applied also to five cases in this category which were infected at the time of admission. In one instance (Case 23), complicated by infection with *Staphylococcus aureus* on admission and later by measles, forty-two days were required for complete healing. Of the five patients treated without cleansing four were completely healed within six to fourteen days (average eight and one-quarter days), and one (infected) healed in eighteen days.

The four cases of combined second and third degree burns showed complete healing of the second degree areas within fourteen days. The third degree areas healed by granulation between nineteen and thirty-two days, except in one case which required grafting.

For the sake of completeness sulfanilamide levels were taken at convenient time

TABLE I

Case	Degree and Area	Cause of Burn	First Aid Treatment	Hospital Treatment	Results
1	2° R. palm, flexor surface, all fingers	Hot exhaust pipe	Tannic acid oint. 24 hours	Cleansed, débrided, film	Complete healing 10 days
2	2° Abdomen	Scalded	Butter	Cleansed, blebs excised, film	Complete healing 5 days
3	2° Hands 6 sq. in.	Hot water, alkaline soap	No treatment for 24 hours	Cleansed, blebs excised, film	Complete healing 8 days
4	2° R. forearm 6 sq. in.	Hot pipe	Salve (?) for 2 days	Cleansed, blebs excised, film	Complete healing 7 days
5	2° Shoulders	Sunburn (severe)	None for 2 days	Blebs excised, film	Complete healing 6 days
6	2° Hands 8 sq. in.	Hot water, alkaline soap	Mercurochrome for 2 days	Cleansed, blebs excised, film applied	Complete healing 6 days
7	2° Hands 4 sq. in.	Hot water, alkaline soap	Ointment (?) for 1 day	Blebs excised, film	Complete healing 6 days
8	2° Hands 4 sq. in.	Hot water, alkaline soap	Tannic acid oint. for 1 day	Cleansed, blebs excised, film	Complete healing 5 days
9	1,2° Generalized 2° chest and thighs; 75%	Severe sunburn	None for 4 days	Blebs excised, film	Complete healing 6 days
10	2° L. hand 3 sq. in.	Hot water, alkaline soap	Tannic acid oint. for 3 days	Cleansed, blebs excised, film	Complete healing 4 days
11	2° L. hand 3 sq. in.	Hot water, alkaline soap	Noxema for 2 days	Cleansed, blebs excised, film	Complete healing 4 days
12	2° Hands 4 sq. in.	Hot water, alkaline soap	None for 1 day	Cleansed, blebs excised, film	Complete healing 9 days
13	2,3° Head, hands, R. forearm, 30% knee, thigh	Gasoline fire, rolled on ground	Ointment-1st aid at Evac. Hosp., sent here 36 hrs. after injury	Cleansed, débrided, film	Complete healing of 2° 14 days. 3° grafted
14*	2° R. forearm 20 sq. in.	Hot grease	Gauze	Film only	Infected. Staph. aureus lymphangitis; film used 7 days; hot compresses necessary; complete healing 18 days
15*	2° R. ankle 30 sq. in.	Stepped in boiling water	None	Blebs excised, film	Complete healing 14 days
16*	2° R. wrist 20 sq. in.	Steam, 36 hrs. before admission	Tannic acid oint. after injury. (Staph. aureus on admission)	Cleansed, film	Complete healing 6 days
17*	1° R. hand 2° L. hand 3° Thighs 10%—Total	Exploding oil can	Tannic acid oint.	Cleansed, blebs excised, film	Complete healing 1, 2° 12 days; 3° healed by granulation 32 days
18*	1° Face 2° Right hand 40 sq. in.	Exploding oil can	Tannic acid oint.	Hand cleansed, blebs excised, film	Complete healing 12 days; Pickrell's solution to face
19*	2° L. leg 10 sq. in.	Gasoline explosion	Sulfathiazole oint. 6 days; infected	Cleansed, débrided, film	Complete healing 7 days
20	2° Legs 8 sq. in.	Brush fire	Picric acid for 7 days; infected	Cleansed, compresses 5 days, then film	Complete healing 9 days
21	1° Face 2° Hands 12% Forearms	Gasoline explosion	Sulfathiazole oint. for 12 hours	Cleansed, blebs excised, film to rt. hand and forearm	Complete healing 19 days
22	1° Face 2° Hands 12%	Gasoline explosion	Sulfathiazole oint. for 3 days	Cleansed, blebs excised, film, Pickrell's solution to face	Complete healing 8 days

TABLE I (*Continued*)

Case	Degree and Area	Cause of Burn	First Aid Treatment	Hospital Treatment	Results
23	2° L. leg 20 sq. in.	Fire	Sulfathiazole oint., six days infected. (Staph. aureus)	Cleansed, com- pressed, 3 days, then film	Developed measles; infection persisted (Staph. aureus) healing 42 days
24	2° Fingers 3 sq. in.	Hot water, alkaline soap	None for 1 day	Cleansed, blebs ex- cised, film	Complete healing 8 days
25	2° L. forearm 18 sq. in.	Scalded	None	Cleansed, blebs ex- cised, film	Complete healing 6 days
26	2° Hands 4 sq. in.	Hot water, alkaline soap	None	Cleansed, blebs ex- cised, film	Complete healing 6 days
27	2° Hands 3 sq. in.	Hot water, alkaline soap	None for 1 day	Cleansed, blebs ex- cised, film	Complete healing 12 days
28	2° Hands 4 sq. in.	Hot water, alkaline soap	None	Cleansed, blebs ex- cised, film	Complete healing 5 days
29	2° Hands 3 sq. in.	Hot water, alkaline soap	None for 1 day	Cleansed, blebs ex- cised, film	Complete healing 6 days
30	2° R. hand 2 sq. in.	Hot water	None	Cleansed, blebs ex- cised, film	Complete healing 4 days
31	2° R. hand 4 sq. in.	Hot water, alkaline soap	None for 1 day	Cleansed, blebs ex- cised, film	Complete healing 5 days
32	2° R. hand 2 sq. in.	Hot water, alkaline soap	None for 1 day	Cleansed, blebs ex- cised, film	Complete healing 8 days
33	2° R. hand 2 sq. in.	Hot water, alkaline soap	None for 1 day	Cleansed, blebs ex- cised, film	Complete healing 11 days
34†	2° Legs 56 sq. in.	Cement (wading in cement)	Ichthyol oint. for 1 day, sulfathiazole oint. for 3 days, (infected Staph. aureus)	Cleansed, compresses for 5 days, then film	Complete healing 8 days
35†	2° Legs 60 sq. in.	Cement (wading in cement)	Ichthyol oint. for 1 day, sulfathiazole oint. for 3 days, infected	Cleansed, compresses 4 days, then film	Complete healing 8 days
36†	2° L. hand; all fin- gers	Exploding cigarette lighter	None	Cleansed, blebs ex- cised, film	Complete healing 9 days
37	2° R. hand, 3 sq. in.	Hot water, alkaline soap	None for 1 day	Cleansed, blebs ex- cised, film	Complete healing 9 days
38	2,3° L. ankle 50 sq. in.	Stepped in boiling eggplant	Boric acid oint. for 2 hours	Cleansed, blebs ex- cised, film	Complete healing 2° area 14 days; 3° areas infected; healed 23 days
39	2° Hands 4 sq. in.	Hot water, alkaline soap	None for 1 day	Cleansed, blebs ex- cised, film	Complete healing 5 days
40	2° R. hand 4 sq. in.	Hot water, alkaline soap	Blebs punctured with pin 7 days ago	Cleansed, blebs ex- cised, film	Complete healing 7 days
41	2° Hands 4 sq. in.	Hot water, alkaline soap	Not any for 1 day	Cleansed, blebs ex- cised, film	Complete healing 6 days
42	2° L. hand 3 sq. in.	Hot water, alkaline soap	Not any for 2 days	Cleansed, blebs ex- cised, film	Complete healing 7 days
43	2° Hands 8 sq. in.	Hot water, alkaline soap	Not any for 1 day	Cleansed, blebs ex- cised, film	Complete healing 8 days

\* These patients were treated with a film containing 10 per cent sulfanilamide only.

† The film used in these cases contained  $\frac{1}{2}$  per cent proflavine as well as the sulfonamides.

intervals during the course of treatment. These were found to vary according to the size and depth of the burn from a trace to 8.5 mg. per cent, expressed as sulfanilamide equivalent. In one case (No. 13) sulfanilamide determinations were made on three subsequent days after a single application of the film and showed blood levels of 7.6, 7.1, and 8.5 mg. per cent, respectively. This indicates a slow resorption since sulfonamides were still being absorbed approximately seventy-two hours after application. This observation agrees with that of Hare and Clark,<sup>13</sup> who found that embedding of sulfonamides in methylcellulose retards absorption considerably. Toxic reactions due to sulfonamides were not seen in any of these cases.

#### COMMENTS

When this study was started, the topical use of sulfonamides for prevention of wound infections was widely accepted. Since then the value of locally applied sulfonamides in the treatment of burns has become doubtful,<sup>10</sup> although Whipple<sup>2</sup> believes that the local use of sulfonamides in the treatment of burns shows promise and states, "The benefits of these amazing drugs will depend upon finding their optimum ionization and pH in proper media."

We can safely conclude from the results obtained in this series that the healing time with this treatment compares favorably with most of the accepted methods of therapy. The film appears to possess an outstanding advantage in that it forms a protective transparent coating which is not removed until full healing has occurred. Painful redressings are thus eliminated and injury to partially devitalized structures and fragile newly growing epithelium is prevented. Contamination was reduced to a minimum in our series. Observation of strict aseptic precautions and application of pressure dressing were undoubtedly responsible for the good results obtained and in the light of recent knowledge it is

doubtful whether the sulfonamides in the film were of any benefit.

Our experience essentially confirms that of Andrus, et al.<sup>6</sup> in that we find that the film can be most conveniently used in combination with pressure dressing. We also believe that in some emergencies and on the battlefield it is of advantage because it can be distributed with a minimum of bulk yet in sterile form.

#### SUMMARY

Results obtained with a simple method of local treatment of burns consisting of the application of a transparent hydrophilic film containing approximately 30 per cent sulfonamide, and of pressure dressing have been reported. The film can be applied easily and by virtue of its transparency, periodic inspection of the burned area is possible without disturbing the lesion. It can be used conveniently under a pressure dressing so that full advantage is taken of this well recognized method for suppression of lymph flow. The sulfonamide in the film did not seem to delay healing noticeably. The immediate relief of pain after application and the favorable rate of healing obtained in these cases suggests that the method of therapy described is worthy of further consideration.

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IT should be the aim of every medical man to treat cases of burns in such a way that a minimum amount of scar tissue is produced in the healing processes. The mortality rate due to burns varies with the area of the burn; it is the extent of the burn rather than the depth which endangers life. If more than a quarter of the surface area of the body is burnt there is a serious threat to life.

From "Surgery of Modern Warfare" edited by Hamilton Bailey (The Williams and Wilkins Company).

# Case Reports

## BIZARRE TYPES AND LOCATIONS OF LIPOMAS\*

HAROLD D. CAYLOR, M.D.

Diplomate of the American Board of Surgery; General Surgeon, Caylor-Nickel Clinic

BLUFFTON, INDIANA

**W**E should like to direct attention to some unusual types of these simple, common tumors, and to peculiar locations where they occur and simulations that they make. Brief case reports illustrate the salient features of each type and group.

Lipomas are one of the most common tumors. They may occur anywhere on the body and may even cause death by growth and pressure on vital organs.<sup>1</sup> These tumors develop more frequently in women than men (3 to 2)<sup>1</sup> and they occur chiefly between the ages of twenty to fifty years.<sup>2</sup> Certain regions of the body are frequent sites of lipomas, as for example, the back of the neck, forearms, axilla,<sup>1</sup> buttock and upper thighs<sup>2</sup> and they seldom occur in the face, scalp, legs, and inguinal region.<sup>3</sup> Adair, Pack, and Farrior, in a series of 134 patients studied, found 6.7 per cent had multiple lipomas. In a simple classification, these observers devised three groups of lipomas: (1) subcutaneous, (2) intermuscular, and (3) visceral. Lipomas transilluminate and those in the breast sometimes present a very special problem.<sup>1</sup> Radiographic studies of deep lipomas frequently yield valuable information according to Brown and Grollman. Nicolas Tagliavacche was among the first to make a preoperative roentgenologic diagnosis of lipoma.<sup>4</sup> Silberman, Hunt and Bisgard, and Templeton have contributed further information of value in the preoperative diagnosis of lipomas by radiographic means.

Malignant changes in lipomas and their combination with other tumors as fibromyxolipoma, etc., do not come within the scope of the study.

### LIPOMA ASSOCIATED WITH AND SIMULATING HERNIA

Lipomas occasionally occur in the inguinal and femoral canals and simulate hernias or occur associated with hernias. Watson, in 1935, discussed such tumors. He noted that they are usually attached to the spermatic cord or sac (if one is present) near the internal ring. The diagnosis in these cases is the most difficult, especially if the tumor appears suddenly after a strain with pain, nausea, and vomiting.

Not infrequently these lipomas are diagnosed as hernias and the patient is advised to wear a truss and frequently does. At times the pressure of the truss on the lipoma makes it tender. Occasionally, the lipoma may strangulate and appear exactly as a strangulated hernia. Mazzarelli reported a lipoma of the left inguinal region of a man, aged sixty-six years. At first this swelling was walnut size. It gradually increased and was as large as a turkey egg when he was admitted for examination. A diagnosis of hernia had been made and for two years the patient had worn a truss. After examination Mazzarelli made a diagnosis of a direct inguinal hernia containing omentum. Surgical intervention under local anesthesia revealed a multilobulated lipoma

\* From the Caylor-Nickel Clinic, Bluffton, Indiana.

in the inguinal canal attached to the peritoneum by a fine cord. The author speculated as to the explanation for the development of the lipoma and symptomatology.

We have had two cases of a lipoma simulating a hernia and two of a lipoma associated with a hernia.

#### CASE REPORTS

**CASE I.** V. B., a schoolteacher, aged twenty-two years, was admitted to the Clinic Hospital as an emergency. She complained of a pain and mass in her left groin and thigh. Ten days before her admittance, after she had lifted some baskets of fruit in her father's store, she had noticed soreness in her groin and had felt a "lump" there. On the evening of her admittance while playing volley ball at her school she again had a pain in the groin and thigh. She felt a "lump" again. This time the mass was very tender. She was nauseated but did not vomit.

Physical examination revealed a well nourished, acutely ill young woman; blood pressure 120/80; pulse 80 and temperature 98.0°F. The most important physical finding was a mass about 4 cm. in diameter in the left groin just below Poupart's ligament. The femoral artery seemed to be lateral to the mass. Attempts to press the mass back into the abdomen were painful and unsuccessful. A single urine examination revealed a specific gravity of 1015, acid reaction, no albumin, few pus cells. Blood examination was as follows: Hemoglobin 93 per cent Sahli; erythrocytes 4.47 million; leukocytes 10,500; Mazzini negative.

A tentative diagnosis was made of a strangulated femoral hernia and immediate operation was offered and accepted by the patient.

Operation was performed at the Clinic Hospital under cyclopropane-oxygen anesthesia. The incision was made parallel to Poupart's ligament. The hernia sac was found and isolated above and below the ligament. The abdominal cavity was opened and the sac inverted, ligated and removed. It measured approximately 3 by 2 by 1 cm. A small bit of omentum had been strangulated in the hernia sac. The omentum involved was not gangrenous although its blood supply had been somewhat interfered with. The aperture which was the site of the herniation

was closed by No. 2 chromic sutures extending from Poupart's ligament to the pectenous muscle. In the thigh superficial to the femoral hernia was a lipoma 4 by 3 by 2 cm. This was removed. This lipoma was the mass felt before operation and assumed to be a strangulated femoral hernia.

The patient left the hospital with her wound completely healed fourteen days after the surgical procedure.

**CASE II.** *Lipoma Simulating an Inguinal Hernia:* R. C., aged forty-eight, married, a farmer, came to the clinic complaining of recurring "nervous breakdowns" and heart trouble. In the course of his examination a soft mass was found protruding from the right external inguinal ring. This had been present many years. The patient volunteered the information that he had been told this was a hernia by many doctors and at one time had worn a truss on the mass with no effect. One of his physicians had suggested that this might be a "fat tumor." Laboratory data revealed: Urine specific gravity 1017; acid reaction; no significant microscopic findings. hemoglobin 99 per cent Sahli; erythrocytes 4.31 million; leukocytes 6700; Mazzini negative; blood pressure 90/68; pulse 90 and irregular. Electrocardiographic studies revealed an auricular fibrillation. A diagnosis of chronic nervous exhaustion, hypotension, and auricular fibrillation was made and the patient was under medical management for some weeks and showed clinical improvement. He then suggested that he have the hernia investigated. A lipoma of the inguinal canal was suspected.

Operation was performed at the Clinic Hospital under cyclopropane-oxygen. The incision was made parallel to Poupart's ligament and extended from near the symphysis almost to the anterior superior spine of the ilium. There was a fatty sac-like mass 5 by 3 by 2 cm. extending through the external ring. The fascia of the external oblique muscle was split parallel to its fibers and 4 to 5 cm. above the internal ring. A large mass of fat filled the inguinal canal. At first it seemed that this was a hernia sac filled with omentum but careful dissection revealed the mass to be a lipoma 22 by 12 by 3 cm., filling the inguinal canal and extending through the external ring. The lipoma was dissected from the cord and adjacent structures. (Fig. 1.) Exploration of the femoral canal revealed no hernia.

The spermatic cord was transplanted subcutaneously and an imbrication type of closure made using No. 2 chromic catgut. The operation was easily accomplished after

bend forward. One physician had told the patient this was a "rupture" and the patient had worn a truss for some months with no effect on the lesion.

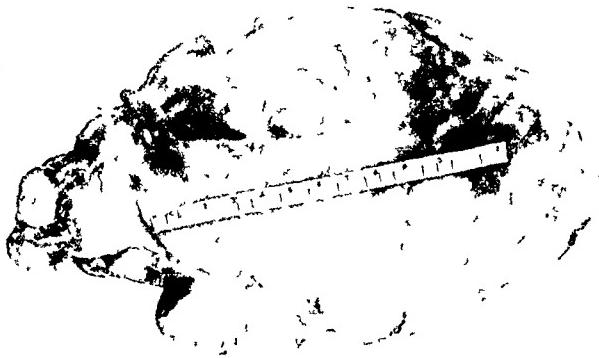


FIG. 1. Case 1. Lipoma; the portion to the left of the end of ruler marked metric extruded through external ring. The remainder of tumor was in inguinal canal.

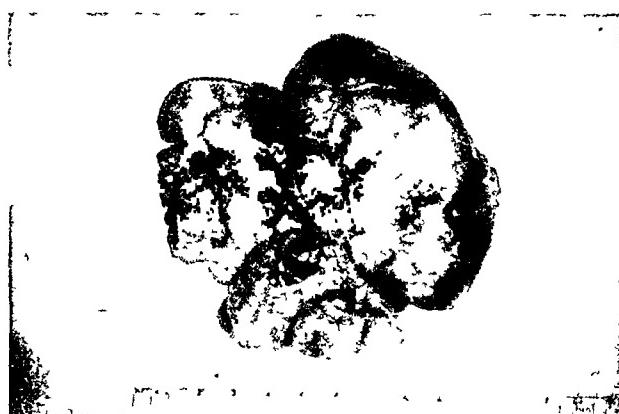


FIG. 2. Case III. Lipoma; the lobule of tumor closest to ruler extruded from external inguinal ring.

structures were identified and the true situation disclosed. The skin was closed with nylon. The patient was a risk 2 because of auricular fibrillation. The patient led an uneventful convalescence and left the hospital in twenty days with the wound healed.

**CASE III.** *Lipoma Simulating Hernia:* E. C., machinist, aged forty-eight years, married, the father of two living children, came to the clinic complaining of psoriasis, present for twenty-two years, and a tumor of the right groin present for two years. This mass in the right inguinal region was first noticed as a small "kernel" which had gradually enlarged to the size of a small orange. This mass was not tender but it did "bother" the patient when he walked and especially when he would

Physical examination revealed the following: weight 170 pounds; blood pressure 150/110; pulse 88; temperature 98.0°F. There were many red macular scaling lesions on the trunk and extremities (psoriasis) and a soft tumor in the right groin about 10 by 5 cm.

Laboratory examination of the urine revealed: specific gravity of 1028, acid reaction, no sugar or albumin and an occasional pus cell. The blood examination revealed: hemoglobin of 82 per cent (photolometer); erythrocytes 4.2 million; leukocytes 9800, Mazzini negative.

A tentative diagnosis was made of an indirect inguinal hernia with omentum in the sac or a lipoma of inguinal canal. An exploratory operation was advised. The patient accepted.

Operation was performed at the Clinic Hospital under cyclopropane-oxygen anesthesia. The incision was made parallel to Poupart's ligament. The fascia of the external oblique muscle was incised parallel to its fibers and a lipoma measuring 13 by 8 by 4 cm. was found. A portion of the lipoma extruded through the external inguinal ring but most of the tumor was in the inguinal canal. (Fig. 2.) One tongue of lipoma extended down toward the thigh. The incision in the fascia was closed with No. 2 chromic gut and the skin was sutured with nylon.

This patient's convalescence was uneventful and he left the hospital within two weeks with his wound completely healed.

**CASE IV. Lipoma Associated with Epigastric Hernia:** R. G., aged thirty-nine years, married, a farmer, came to the clinic complaining of a "lump" in the middle of his abdomen about halfway between the naval and the xiphoid. The knot had been present for sixteen years. At first the nodule was about the size of the end of the finger but it had gradually enlarged until at the time of his examination the tumor was about 4 by 3 by 3 cm. Soon after the tumor was discovered the patient had gone to a physician who told him this was a fat tumor and to leave it alone unless it caused symptoms. During the last two months when the patient would lift, he would have a sharp pain in the "lump" and he would have to bend forward before he could get relief. In the past two years the lesion had doubled in size. The only other complaint the patient had was multiple attacks of appendicitis.

Physical examination revealed a well nourished partly gray-haired man, blood pressure 124/84; pulse 72; temperature 99.0°F. The pertinent point in the physical examination was a mass 3 by 4 by 3 cm. in the midline approximately halfway between the umbilicus and the xiphoid process. The opening in the fascia was about 1 cm. in diameter. Palpation of the sac revealed lobulated substance that felt like fat, probably of the omentum. This fat could not be pushed back through the hernia opening into the peritoneal cavity. There was also tenderness in the right lower quadrant of the abdomen near McBurney's point. Urine: specific gravity 1021, acid reaction, no sugar, albumin, or casts. Blood examination revealed hemoglobin 90 per cent

(photolometer); erythrocytes 4.52 million; leukocytes 7250.

A diagnosis was made of an epigastric



FIG. 3. Case v. Lipoma simulating thyroglossal duct. The long tongue of tissue extended upward toward hyoid bone.

hernia probably containing omentum and chronic recurring appendicitis. Surgical therapy for both conditions was offered and accepted by the patient.

Operation was performed at the Clinic Hospital under cyclopropane-oxygen anesthesia. A midline incision was made through the skin and the mass was visualized after dissecting the skin flaps backward. The mass proved to be a lobular lipoma about 4 by 3 by 3 cm. and attached to this was the sac of an epigastric hernia. The opening of this hernia in the fascia was about 1 cm. in diameter. The fascia was incised and the neck of the sac isolated and cut off. There was omentum in the sac. The fascia at the edges of the lipoma was very thin. The sac was excised together with the lipoma. The peritoneum was closed with No. 1 plain catgut. The fascia layers were dissected backward and then closure of the fascia made by imbrication with No. 2 chromic catgut. The closure was adequate. The skin was closed with nylon. Through a McBurney incision a chronically inflamed appendix was removed.

The postoperative course of this patient was uneventful except that there was an accumulation of serum in the subcutaneous tissues of the hernioplasty. The patient left

the hospital on the fourteenth postoperative day.

CASE V. *Lipoma Simulating Thyroglossal Duct Cyst and Sinus Tract:* J. O. H., a farmer aged forty-nine years, married, the father of ten living children, came to the clinic complaining of "fainting spells" and a "lump" in the front of his neck. The fainting spells had been present about six months. These attacks were associated with dimming of vision, bad taste, and dry mouth. If the patient could lie down when he felt this aura, the episode might pass off, otherwise, the patient would give a cry, be unconscious for five to ten minutes, froth at the mouth and usually sleep for half an hour after the seizure passed.

The lump in the front of the neck below the Adam's apple had been present for a year or two. It had gradually enlarged and the patient was conscious of it when he "dressed up for Sunday" and wore a tight collar. The lesion had gradually enlarged and moved up and down when he would swallow.

Physical examination revealed a slender man; blood pressure 108/80; pulse 60; temperature 98.0°F., urine: specific gravity 1017, alkaline, 2+ phosphates, 1+ pus cells; blood: hemoglobin 81 per cent Sahli, erythrocytes 3.85 million; leukocytes 5950, blood urea 48, blood sugar 75, basal metabolic rate -7 per cent; blood Kline-negative. There was a soft mass in the front of the neck just above the thoracic aperture. This mass was between 2 and 3 cm. in diameter. When the patient swallowed this nodule moved for it was apparently attached to the trachea.

A tentative diagnosis was made of idiopathic epilepsy and an uncertified tumor of subcutaneous tissues of the front of neck either a thyroglossal duct cyst or lipoma.

Appropriate medical management was inaugurated for the epilepsy and operative removal of the lesion in the neck planned.

Operation was performed at the Clinic Hospital under 2 per cent novocain infiltration anesthesia. A Crile modification of the Kocher incision was used. When the platysma muscle and superficial cervical fascia were incised, a lobular lipoma was discovered on the isthmus of the thyroid gland and trachea. This lipoma, which was about 2 cm. in diameter, was freed from adjacent structures and these included the strap muscles, the anterior jugular vein and the trachea. There was a tongue of this lipoma about 3 cm. long which

extended upward on the trachea and larynx to the level of the hyoid bone. (Fig. 3.) The whole dissection was carried out under local anesthesia. The bleeding points were ligated and a rubber dam wick was left in the fossa. The skin was closed with clips. Two days after the operation the drain was removed and four days postoperatively the patient went home to return later for removal of skin closure.

CASE VI. *Lipoma Causing Pressure Symptoms:* W. W. R., auditor, aged forty-nine years, married, father of five children, came to the clinic complaining of numbness for six months in his right forearm and hand near the thumb and first finger, and a tumor on top of the right shoulder present for three or four years. The past history, so far as diseases were concerned, was unimportant. The distress in the hand and arm would come on as he sat working at his desk and as the day passed the distress increased.

The tumor on top of the shoulder had gradually enlarged until he would notice pressure on it from his suspenders or vest, or tight underwear, or strap of bathing suit.

Physical examination revealed a well nourished man; blood pressure 126/78; pulse 74; temperature 98.6°F.; urine: specific gravity 1020, acid reaction, occasional pus cells, negative for sugar or albumin; blood study revealed hemoglobin 82 per cent Sahli, erythrocytes 4.2 million, leukocytes 6540.

The most interesting feature of physical examination was a soft tumor about 2 to 3 cm. in diameter, apparently just under the superficial fascia of the right shoulder. The tumor was in the groove between the top of the shoulder joint and clavicle, just where pressure by a suspender strap or underwear would normally come. Palpation revealed tongues of tissue which seemed to go backward under the trapezius muscle and anteriorly under the clavicle. Neurological examination revealed no cause for the numbness complained of and it was doubtful if the tumor could cause the distress. The patient was convinced that the tumor was the cause of the numbness and insisted that if we did not excise the lesion he would "go to someone who would."

Operation was performed at the Wells County Hospital under ethylene oxygen anesthetic. The incision was made anteroposterior over the top of the shoulder and tumor. When the superficial fascia was incised a lobulated

lipoma "popped up." This portion was about twice the size of the palpable portion before operative interference. Tongues of the tumor extended backward and downward under the edge of the trapezius muscle and forward and downward under the clavicle. The dissection was tedious but the tumor was apparently all removed. The greatest dimensions of the tumor were approximately 8 by 6 by 3 cm. A rubber dam drain was inserted into the space formerly occupied by the lesion. Closure of the skin was made with dermol. As soon as the patient awakened he noticed no numbness and when he left the hospital, five days later, he still was free of any symptoms of numbness in the hand and forearm.

**CASE VII.** Mrs. A. J., aged thirty-nine years, married, mother of two children, a factory worker, complained of tumors of each buttock and pains radiating down legs. The patient had these masses near the gluteal folds for many years. They had gradually enlarged but gave no symptoms except for their presence. About six months before coming for examination, the patient began to work at a factory and in the course of her work she sat on a hard stool or chair. She soon noticed pain radiating down the back of her thighs and in her buttock. The tumors of the buttocks became tender and the more she sat the more severe and disturbing became the pain down the legs. From this distress she sought relief.

Physical examination revealed the following: blood pressure 130/90; pulse 80; temperature 98.6°F.; urine: specific gravity 1012, acid reaction, no albumin, no sugar, occasional pus cells; hemoglobin 75 per cent Sahli; erythrocytes 3.75 million; leukocytes 4600. The pertinent features of the physical examination were tumors of each buttock near the gluteal line. These lesions were each approximately 15 by 5 cm. in their greatest dimensions. Since no other source could be found for the distress the patient was advised to have the tumors removed and she accepted.

Operation was performed at the Clinic Hospital under cyclopropane-oxygen anesthesia. Incisions were made over the lipoma in each buttock and they were each removed by blunt and sharp dissection. Some portions of the lipomas were encapsulated, others were not. Sharp dissection was required to free them from their attachment to the subcutaneous fat and gluteal muscles. Both lipomas were about the same size and their average dimen-

sions were 15 by 10 by 5 cm. Cigarette drains were inserted in the space left by the lipoma and the subcutaneous tissue was drawn together with No. 0 plain catgut. The skin was closed with interrupted nylon sutures. The drains were removed in two days and the patient was able to leave the hospital on the eleventh postoperative day. The patient returned in one and two months and said that she was free from pain down her legs and thighs.

#### COMMENT

Lipomas simulating hernias are most disconcerting and difficult to diagnose, and their true identity is not always established until a surgical procedure is performed. When lipomas occur, associated with hernias, the situation is most baffling and when a lipoma occurs with a strangulated hernia, the acme of disconcertion is attained in this set of circumstances.

It seems reasonable to suppose in some cases that a lipoma may have caused pressure on fascia sufficient to thin it and with the lipoma as the wedge to force herniation through fascia planes (Case IV) or through an inguinal ring. The simulations of lipomas are most curious, aping of hernia and of a thyro-glossal duct cyst.

The pressure symptoms are the least intriguing of the whole group but one cannot disregard lipomas as cause of referred pains, particularly along the extremities.

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# DIVERTICULOSIS AND DIVERTICULITIS OF THE COLON

## CASE REPORT OF A FOURTEEN YEAR OLD PATIENT

PASQUALE D. BADIA, M.D.

Assistant Surgeon, Morristown City Hospital

NEW YORK, NEW YORK

THIS case is reported because of the age of the patient (he was fourteen years old when it was first discovered

beginning of the present century that Edwin Beer, W. J. Mayo, Moynihan et al. began to give to the medical world the true

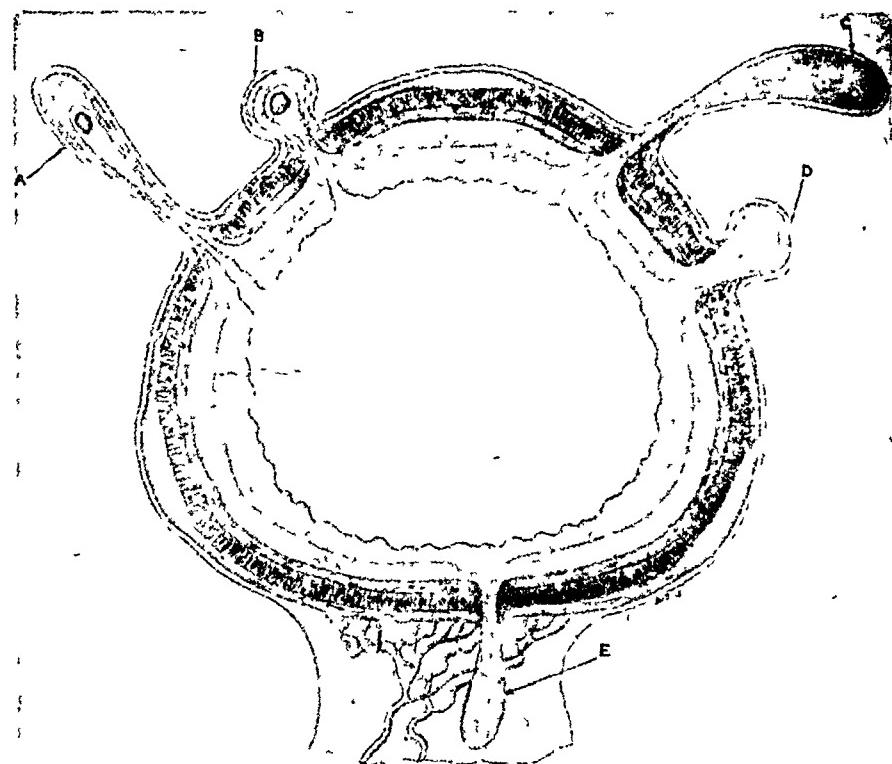


FIG. 1. Various forms of diverticula: A, true diverticulum in epiploic appendix with foreign body; B, true diverticulum with foreign body; C, false diverticulum in epiploic appendix; D, false diverticulum; E, intermesenteric diverticulum. (From ERDMANN, J. F. Diverticulitis and diverticulosis. *J. A. M. A.*, 99: 1125-1128, 1932.)

that he had diverticulosis) and because he has been under my care for twelve years.

Diverticulosis is a condition in which many diverticula exist in any portion of the intestine, usually the colon.

In the second half of the nineteenth century some investigations were conducted on the subject but the information was not conclusive. It was only at the

import of diverticula in the alimentary canal. Since then, the literature on the subject has become quite voluminous with reports based on clinical and pathological studies so as to assure a clearer interpretation of the symptoms both for diagnosis and for treatment. As the roentgen rays became more widely used in the study of the alimentary tract, the radiologists, about 1914, began to give an account of

their observations. Since then the diagnosis of uncomplicated diverticulosis has depended a great deal upon radiographic evidence.

toneal covering. The onset of an inflammatory process in any of these sacculations will create a definite clinical entity called diverticulitis. Some observers have pointed

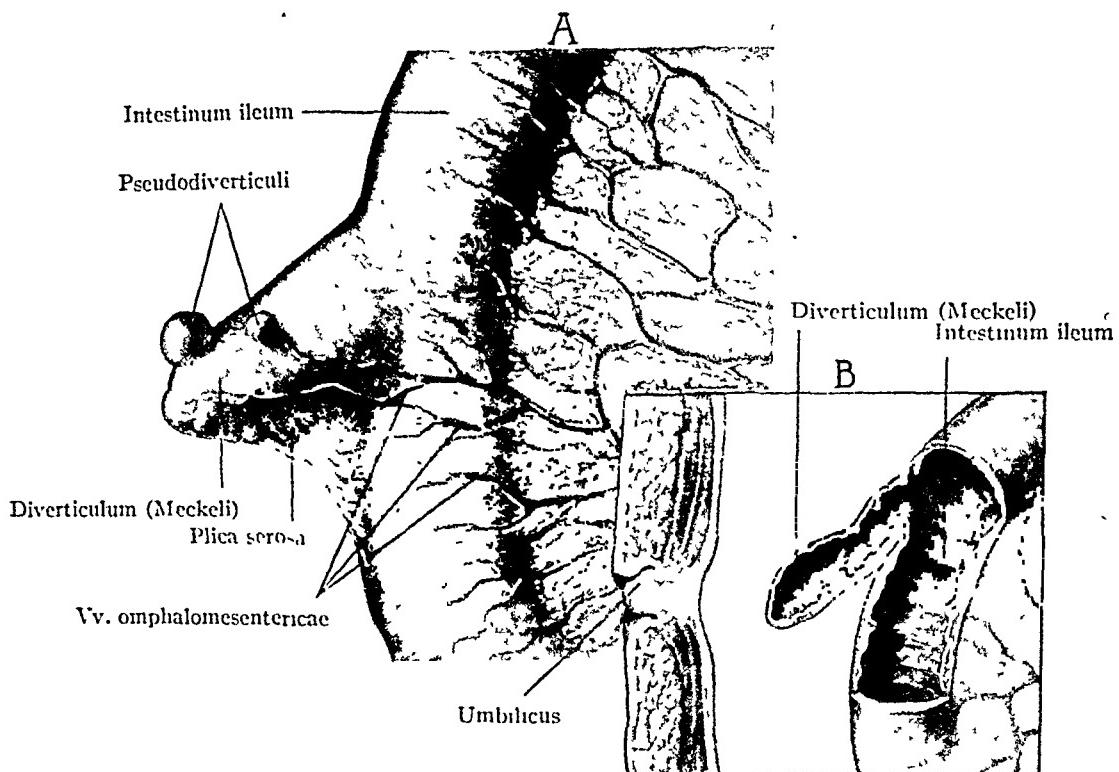


FIG. 2. Ileal diverticulum (of Meckel). A shows the diverticulum along which lie the omphalo (vitello)-intestinal vessels; B shows a section removed from the ileum and from the diverticulum. (After Cullen.) (From CALLANDER, C. LATIMER. *Surgical Anatomy*. 2nd ed. Philadelphia, 1943. W. B. Saunders.)

**Definition.** Diverticula are pouch-like protrusions from the alimentary canal. They are herniations of areas of the mucosa and submucosa, through interstices in the muscle coat. Blowouts of the inner tube (mucosa). In the intestine they form projecting-like sacculations and may occur on the mesenteric side; they may be anti-mesenteric or may occur on the lateral wall. In the colon they may develop into parallel rows on either side of the mesocolon.

**Types.** Diverticula may be true or false. A true diverticulum (Meckel's) is one that has all the coats of the intestine. A false diverticulum is one which has all the coats minus the muscularis. The term diverticulosis denotes the presence of sacculations of various sizes protruding from the lumen of the bowel through the mucosa and submucosa, having a peri-

out that diverticulosis is the most common pathological lesion of the colon and that it is responsible for the majority of cases of disease of the colon sent to the surgeon or to the radiologist. However, this opinion is not shared by all investigators.

**Meckel's Diverticulum.** This diverticulum is a true congenital diverticulum due to the persistence of the proximal portion of the omphalomesenteric duct which normally atrophies a few weeks after birth. It is found in about 2 per cent of individuals. It varies up to 30 cm. in length but is usually about the size of a small finger. It is situated one to three feet proximal to the ileocecal junction. They are a common source of melena in infants and children. It may cause volvulus or intussusception. This diverticulum is always a source of danger in the abdo-

men because of its tendency to create intestinal obstruction.

**Etiology.** Several hypotheses have been

deterioration of the muscularis creating a weakness in the muscular wall.

Graser believed that the sacculations

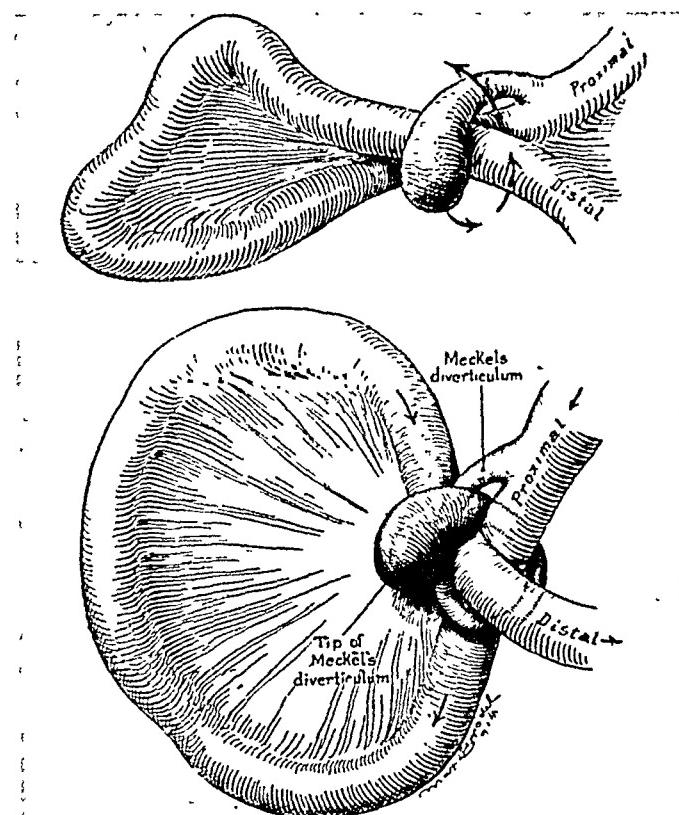


FIG. 3. A diverticulum tying off a loop of small bowel. This indicates the manner in which the obstruction occurred; a Meckel's diverticulum has dropped over a loop of bowel which has been twisted; after passing under the loop, the diverticulum curves upward and passes through the space between the base of the diverticulum and the adjacent small bowel; there is consequent distention of the constricted bowel and complete obstruction has resulted. (Cullen.) (From CALLANDER, C. LATIMER. *Surgical Anatomy*. 2nd ed. Philadelphia, 1943. W. B. Saunders.)

offered to explain the cause of formation of these protrusions. But so far they remain simple theories and the subject is still under discussion. Some investigators maintain that in the obese and asthenic individuals they develop in middle life and are produced by increased intracolonic pressure caused by constipation and frequent drastic cathartics. Others attribute the formation to a process of aging, senile changes, like gray hair and the rugae of the skin, so that in like manner the intestinal wall goes through a process of

formed by following the course of the emerging veins as they reach the serosa through the intestinal wall.

Klebs maintained that the protrusions occurred in relation to points of entry and exit of blood vessels along the mesenteric attachment, believing that the intestinal wall is weak at this point.

Since the false types are of the acquired variety they must be of the pulsion type, and because they occur at any age and appear anywhere in the intestinal tract one is led to believe that a locus minoris

resistentiae is congenitally present in the muscularis. Thus, with a congenital weakness in the muscular coat and with in-

layers of the meso-appendix like small buds and are frequently multiple.

**Age.** Reports indicate that they occur

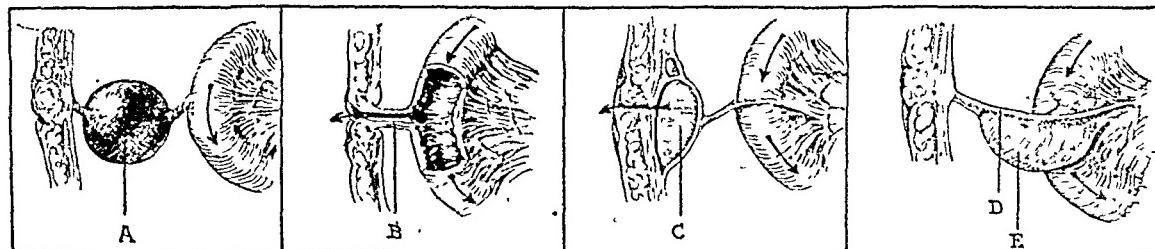


FIG. 4. Varieties of omphalo (vitello)-intestinal pathology. A, cyst caused by torsion of the omphalomesenteric duct; B, patent omphalomesenteric duct; C, cyst of the umbilicus, the result of a remnant of the omphalomesenteric duct; D, fibrous cord from omphalomesenteric vessels; E, Meckel's diverticulum. (After Cullen.) (From CALLANDER, C. LATIMER. *Surgical Anatomy*. 2nd ed. Philadelphia, 1943. W. B. Saunders.)

creased intracolonic pressure, such as caused by constipation, these forces can be the exciting factors. The theories of Klebs and Fraser seem to be fallacious because diverticula are found (the double row observed in the colon) in points which have no relation to blood vessels. While there is no unanimity of opinion as to the cause of production of these sacculations and because they appear at any age, it seems safe to assume and agree with Erdmann, that a congenital weakness must exist in the intestinal wall. This congenital abnormality is felt more with advancing years when muscular tone is diminished not only in the alimentary canal but as a process of aging is shared by the entire body.

**Distribution.** Diverticula occur in any part of the alimentary tract, from the esophagus to the rectum. They are most common in the sigmoid. Eighty-five per cent involve this part of the bowel; the other 15 per cent are shared by the transverse, rectum and descending colon progressively. They are rarely found in the cecum, ascending colon and in the appendix. Diverticula of the large intestine are all of the false type. They may be single or may be present in hundreds; as many as 400 have been found. They may be small or may reach the size of a small plum seed. The appendix presents an incidence of 1.89 per cent. They occur between the

in 5 per cent of all subjects over forty. Most occur after middle life. Some have been reported to occur much earlier. J. Erdmann reported a patient under seven years of age. Race plays no important rôle. Males seem to be affected in a ratio of 2:1 compared with females. At the Mayo Clinic only twenty under forty showed diverticulosis out of 1,819 patients. In his report John Erdmann stated that he, during the course of operation, observed the presence of diverticula scattered through the small as well as the large intestine.

**Symptoms.** Uncomplicated diverticulosis is symptomless. Diverticula sometime aggravate the already existing constipation and increase intestinal toxemia. In the cecum, ascending colon and part of the transverse colon, the feces are in a semi-soft state, but in the left colon, sigmoid and rectum, the water has been absorbed and the feces become harder. Here, stasis is usually present, putrefaction is greater and the formation of gas is more pronounced. Should these hard feces enter the sacculation, it is difficult for these bottleneck protrusions to empty themselves since they have no muscular coat and the neck is smaller than the sac itself. Thus, the hard feces left in these sacculations continue to dehydrate, are subjected to bacterial action and may go on to form fecaliths. These in turn may be the source of irritation, and if inflammation of the

sac wall results, we have the characteristic syndrome called diverticulitis. If the inflammation will assume a chronic nature,

but clinical evidence shows that diverticulitis is by far rarer than disease of the gallbladder or appendix." Willard

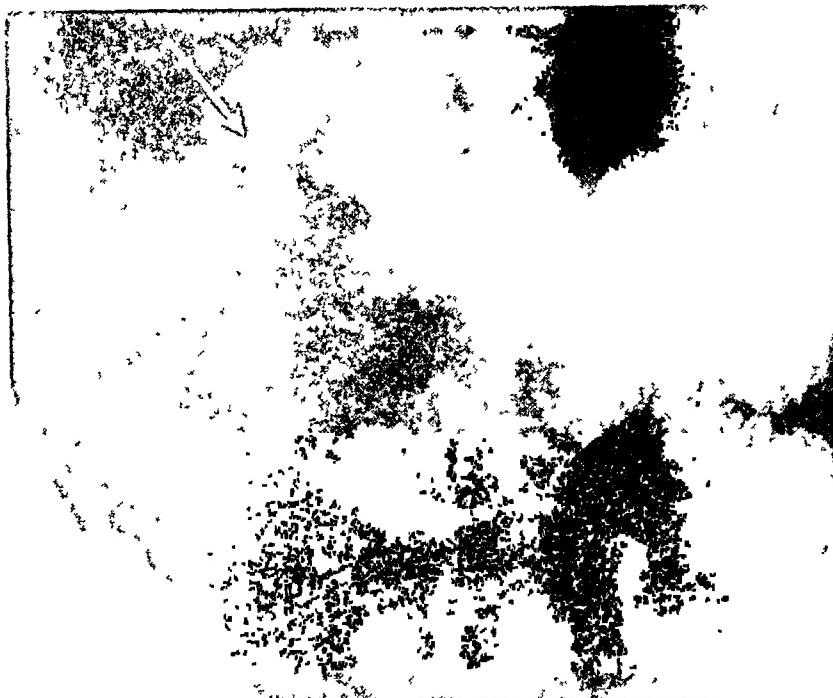


FIG. 5 Diverticulum of duodenum. (From ABELL, IRVING. Diagnosis and treatment of diverticulitis and diverticulosis. *Surg., Gynec. & Obst.*, 60; 370-378, 1935.)

the inflammatory process may extend to the adjacent structure causing peridiverticulitis. This process may involve one or more sacs. This inflammatory process may go on to resolution, may progress to perforation with resultant diffuse suppurative peritonitis, or may go on to abscess formation and may perforate into adjacent structures, vesical bladder, intestines, etc.

Bleeding from the bowel caused by diverticula is reported to have occurred in older individuals. Ochsner and Bargen noted bleeding in 5 per cent of their patients; other investigators have not met with a similar experience. Erdmann has made a very courageous statement: "The presence of diverticula in the intestines merits no greater attention than does the existence of the appendix or gallbladder except that there may be many diverticula, while there is only one appendix and one gallbladder: therefore, ordinarily the chance of acute diverticulitis would be greater,

and Bockus are of a different opinion: "Diverticulosis should not be considered a rare abnormality, because, while diverticula appear to be harmless at the moment, they might have been or will be the seat of inflammation." Such a position is shared by most recent observers. It follows then, that while the physician should not make the patient conscious of the abnormality existing in his alimentary tract, the patient should be warned to eliminate from his diet foodstuffs that favor constipation, such as bran, whole wheat, popcorn, nuts, berries with large seeds, etc. The patient should be encouraged in the use of drugs that favor elimination because the presence of diverticula in the colon constitutes a potential focus of acute or chronic infection and such a condition merits attention. The presence of these pouches in the colon is a direct evidence of weakened intestinal wall. Diverticulosis is usually associated with periods of diarrhea or

periods of constipation and efforts should be directed toward the removal of those forces which have the tendency to increase

covered in a routine x-ray examination. This is the only method by which they may be definitely diagnosed. The barium,

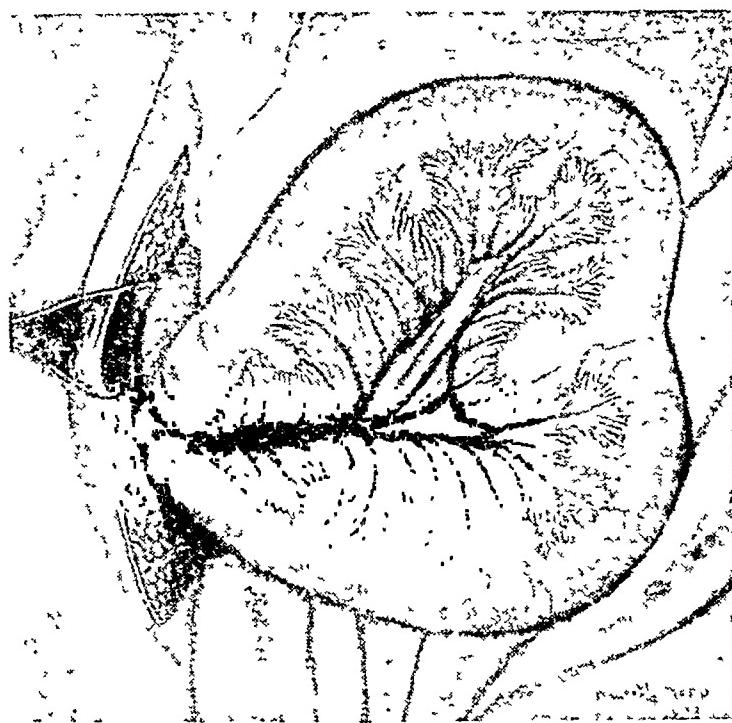


FIG. 6 Diverticula of jejunum with fecalith producing partial obstruction. C. M. Watson. (From ABELL, IRVING. Diagnosis and treatment of diverticulitis and diverticulosis. *Surg., Gynec. & Obst.*, 60: 370-378, 1935.)

intracolonic pressure. Constipation, therefore, must be reduced as much as possible.

In case of resection of the colon in the presence of diverticulitis microscopic examinations should always be made to ascertain the presence of cancer cells. Diverticulitis may be only a coincident factor or both conditions may be present. These abnormalities may give rise, as mentioned above, to severe symptoms demanding appropriate therapy. An infected diverticulum of the cecum or ascending colon may simulate appendicitis and the differential diagnosis cannot be made until the peritoneum is opened. A chronic inflammatory process of the diverticulum may result in great thickening of the wall of the gut causing a partial obstruction of the colon, a condition which is frequently mistaken for carcinoma.

*Diagnosis.* Diverticulosis causes no symptoms. Diverticula are frequently dis-

either meal or enema, used for this purpose may remain in the sacs for a long time, perhaps weeks and even months without producing any untoward effects. Sigmoidoscopic examination may be of value. If the diverticula are lower down, the openings can be seen through the scope. Usually the pouches are higher up and can best be visualized after the barium has been expelled. The sacs will retain some of the shadow-casting media. D. F. Jones states that 12 to 15 per cent of patients with diverticulosis will develop diverticulitis.

When a patient presents himself with the history of left lower abdominal pain or discomfort with flatulence and irregularity of the bowel, diverticulitis should be kept in mind. In females due consideration must be given to structures present in the left pelvic floor. In making the diagnosis of diverticulitis, the age and the aspect of the patient must be considered.

The majority are in the fourth or fifth decade, are short, stocky and overweight. They usually give a history of some dietary

avoid constipating food. Since the condition has a tendency to progress, it is suggested that the colon be x-rayed once or

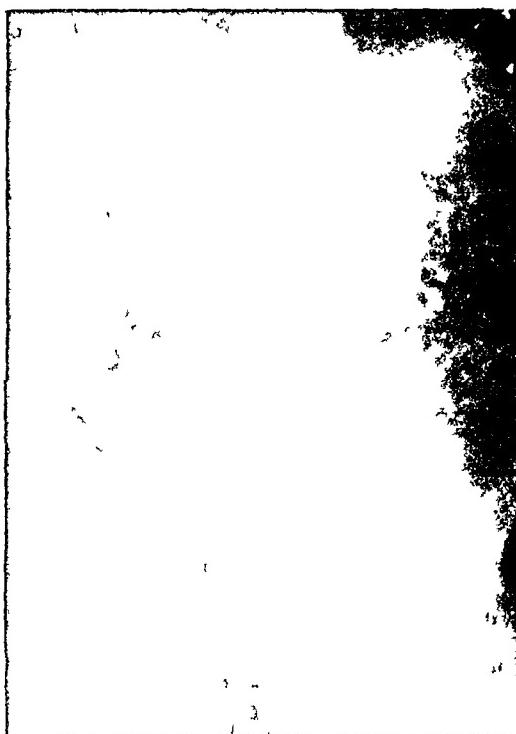


FIG. 7. Reproduction of x-ray of patient taken in October, 1940.



FIG. 8. Reproduction from original x-ray taken of patient in February, 1944.

indiscretion. The onset is characterized by pain in the lower left quadrant associated with nausea or vomiting, rising of temperature and pulse rate followed by tenderness, rebound tenderness and rigidity of the abdomen, usually extending from the left iliac fossa to the mid-hypogastric region. The blood examination presents the usual picture of an acute infection with leukocytosis.

*Treatment.* Diverticula of the colon are considered here. A patient with diverticulosis should be under the care of a physician. Foci of infection which have a tendency to lower body resistance should be eliminated. The patient should pay considerable attention to keep in good health; he should have regular habits, indulge in moderate exercises, discourage overweight and avoid heavy lifting or anything that may increase intracolonic pressure. He should have a simple diet and

twice a year. The administration of mineral oil and agar-agar in liberal doses will help elimination, although some investigators do not place much credence in the efficacy of these drugs. An enema may be given at frequent intervals. Some investigators have given barium or bismuth by mouth at stated intervals. The principle behind this therapy is to allow these drugs to deposit in the sacculations and thus prevent fecal material from entering them. This treatment has not met the favor of most clinics. Most observers divide the treatment for diverticulitis into medical and surgical. A patient with diverticulitis should be kept in bed at least three weeks. Nothing should be given by mouth for the first forty-eight hours. The inflamed colon should be put at rest. The regular amount of water in 5 per cent glucose with saline, at least three quarts per day, should be given parenterally. The application of

heat has been found beneficial. The use of hot fomentation and the electric pad may be applied over the suspected area.

This process facilitates the cleansing of the bowel; and if the water reaches the affected sacculation, it may help to dis-

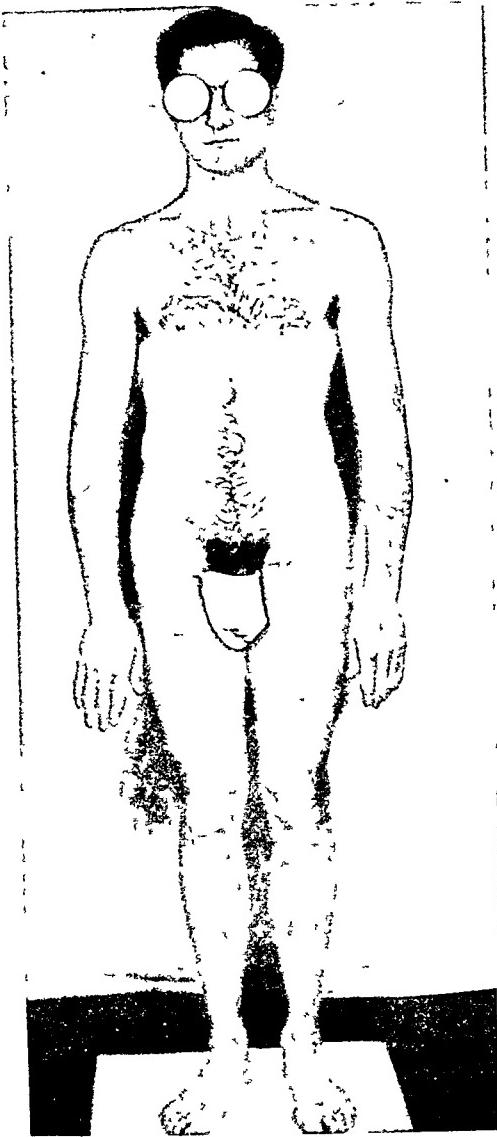


FIG. 9. Frontal view of patient as he looks today.



FIG. 10. Side view of patient as he looks today.

Short wave diathermy used several times a day has proved very efficient. The Elliot treatment is of some value for women but less satisfactory for men. The bag introduced into the vagina with a return flow of hot water seems to be tolerated well by the patient but it is not supported well by males when applied through the rectum. When the tenderness has localized, an ice bag can be applied over the area. Small warm enemas of salt solution can be used.

solve the contents. Retention enemas of warm olive oil given in the knee-chest position are comforting and promote bowel movements. During the attacks some surgeons suggest the use of belladonna and its derivatives. I have had good results with bellafoline. Others believe that these drugs have no therapeutic value in an inflamed diverticulum. If the acute attack subsides, the patient may be treated as a case of diverticulosis.

John Erdmann is of the opinion that as soon as the diagnosis of diverticulitis is made, all patients with acute conditions must be operated upon. He further states, "that there is no more reason to wait or try medical treatment than there is in an acute appendicitis or an acute tubal infection." Such a radical position is not shared by all surgeons. Judicious medical treatment has at times warded off an operation. A victim of diverticulosis may have many attacks before the end comes and if each attack is treated surgically, the patient might go through many an operation.

However, if the symptoms of acute inflammation do not subside with conservative treatment, surgical intervention is deemed necessary. A progressive inflammatory process can be summarized thus: increased pain, rise of temperature and pulse, increased leukocytosis with the general condition of the patient becoming worse.

William R. Jones has divided diverticulitis that requires an operation into five groups: (1) acute conditions which do not subside when treated medically; (2) acute perforation; (3) abscess formation; (4) chronic inflammatory conditions with fistula or obstruction and (5) malignancy.

It is not the scope of this paper to cover all the detailed procedures of each problem. That is left to the orientation of the surgeon.

**Prognosis.** In cases of diverticulosis, in a large percentage of cases, diverticula produce few or no symptoms and, as stated before, are accidentally found. Many investigators believe that diverticulitis (and peridiverticulitis) develops in 12 to 17 per cent of patients. The subject is still under consideration and it may change with more accurate study of all the cases in the various clinics. The results for the surgical treatment of diverticulitis depend on the age, condition of the patient at the time of the attack and the area involved. Daniel Jones stated that operations for

diverticulitis carry a mortality from 12 to 22 per cent. An acute condition of the appendix can easily be removed, whereas the surgical procedure for diverticulitis involves greater risk. Cases of fistula and abscess are serious and require careful surgical judgment. Perforation with diffuse peritonitis carry a very high mortality.

#### CASE REPORT

M. P., twenty-six years old, a white male, junk dealer by trade, was well developed and well nourished. During infancy he had had measles, pertussis and parotitis. He stated that as far back as he could remember the bowel function was never regular. To his recollection his life was associated with abdominal cramps, which annoyed him a great deal periodically. They were so frequent, that whenever he could hide the evidence of these cramps from his mother he would go through that torture gladly to spare himself the enemas which his mother would automatically submit him to. His chief complaints have been (1) flatulence, (2) constipation, associated from time to time with attacks of diarrhea and (3) repeated attacks of crampy-like pains beginning around the umbilicus and extending over the entire left quadrant. His childhood life had been associated with many episodes of constipation, frequent diarrhea and abdominal cramps.

His mother was of the opinion that these attacks of abdominal distress were caused by an improper ingestion of food. She was told that the condition was some form of "enteritis" and since the boy was attending school and no close watch could be kept over his food, she became resigned to the fact that perhaps as the boy would grow the condition might improve. She had become so accustomed to these abdominal symptoms that whenever he would have an attack she would administer a mild laxative (milk of magnesia) or she would give the boy a simple enema. She would put the boy to bed for a day or two, place him on a light diet, mostly fluids, and would give him a soap suds enema. This treatment was continued until the attack subsided.

In the winter of 1934 the boy had a severe and prolonged attack of crampy abdominal pains. These symptoms were too severe and being associated for the first time with nausea

and vomiting, the mother became alarmed and took the boy to my office.

The abdominal examination revealed many points of tenderness around the umbilicus, more marked in the left middle quadrant. The abdomen was soft. No masses could be palpated. No fever was present. The pulse was normal. This episode of abdominal distress was preceded by many watery movements. I ordered the patient to bed for several days. Hot fomentations were applied to the abdomen and the boy was placed on a liquid diet. Small low saline enemas were given every four hours for the first twenty-four hours. As soon as the pain was under control, the enemas and the fomentations were discontinued. At no time during the following days was there any rise in temperature or a rise in pulse rate. The clinical picture remained constant. These vague symptoms, associated with a history of recurrence for many years, led me to suspect the existence of extensive disease somewhere in the alimentary tract.

Several weeks later, when the acute attack had subsided, the gastric series were done with a barium meal and to my surprise I found that the transverse and splenic flexure of the colon was studded with many diverticula. This new evidence finally solved a problem which had been unknown for all the preceding years. What was thought to be a plain case of enteritis, now became clear as a case of diverticulosis. As one, two or many of these diverticula became engorged with material, the pressure caused by this material within these sacs gave the patient all the symptomatology enumerated.

During these past twelve years the patient has been under my observation. He has been instructed to avoid food stuffs that leave a high residue or substances that favor constipation and also to keep his bowels open with mild laxatives. The patient has observed that whenever he would violate these instructions, the abdominal distress would recur. He has also noticed that the use of peanuts in his food would surely precipitate an attack a day or two later.

For the past two years he has scrupulously observed these rules and has faithfully used mineral oil every night. Under this regimen two years have elapsed without any attacks. A question comes to my mind as to whether the presence of these diverticula is responsible

for the marked irritability that the boy experiences whenever he is under tension. The nervous system is so stimulated that he actually suffers trembling fits, is easily frightened, his speech becomes incoherent, etc., so much so that in passing the military examination he was placed in 4F for this condition. How much does the autonomic nervous system play with such extensive disturbance in the alimentary canal? If one recalls the embryo-anatomical course of the vagus with its function and the influence that the vagus plays on the abdominal viscera through the interaction with the abdominal plexuses, one can understand the phenomenon.

#### CONCLUSIONS

1. Diverticulosis and diverticulitis have been properly recognized and treated during recent years.
2. Vague abdominal complaints associated with flatulence, constipation and diarrhea deserve an x-ray examination of the alimentary tract to determine the presence of diverticulosis.
3. Experiments both on human cadavers and on living dogs have not added much information as to causation. Notwithstanding the fact that many prominent surgeons are of the opinion that diverticula are caused by a congenital defect in the anatomical structure of the alimentary canal, in the absence of more definite conclusive evidence, the theory of causation is still under discussion.
4. Diverticulosis occurs in about 5 per cent of the cases investigated for disease of the colon. Approximately from 12 to 15 per cent of persons with diverticulosis will develop diverticulitis.
5. Treatment of diverticulosis and mild diverticulitis is medical and that of severe diverticulitis is surgical.
6. Plastic procedures for the relief of diverticulitis should be preceded by a colostomy or by a cecostomy. The sulfa drugs will play a big rôle in the treatment of these conditions.

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*Intestinal obstruction* may occur from herniation of bowel through the opening in the transverse mesocolon into the lesser peritoneal cavity. Nearly all of the small intestines may enter the lesser peritoneal cavity, protrude through the gastrocolic omentum, and hang in front of the transverse colon. This, as well as secondary adhesions, should be relieved by reoperation.

FROM "Principles and Practice of Surgery" by W. Wayne Babcock  
(Lea & Febiger).

# SOLITARY EOSINOPHILIC GRANULOMA OF BONE\*

BENJAMIN B. GREENBERG, M.D. AND

Adjunct, Orthopedic Surgeon, Mt. Sinai Hospital

ALBERT J. SCHEIN, M.D.

Associate, Orthopedic Surgeon, Mt. Sinai Hospital;  
Assistant Visiting Orthopedic Surgeon,  
Bellevue Hospital

NEW YORK, NEW YORK

**S**OЛИTARY eosinophilic granuloma, according to the literature, is a very rare lesion. As late as July, 1943, only twenty-one cases had been reported although many others may have been recognized and not reported. Of these, fifteen were solitary lesions and only three of them were located in the long bones. Six other cases were described by Green and Farber with multiple lesions involving both long and flat bones, possibly presenting a different clinical entity. We are describing two new cases involving long bones.

From our experience it is likely that the significance of this lesion has been unrecognized in the past. At least, it is being recognized more commonly in the past few years.

Review of the literature is unnecessary here as it has been done recently by Jaffe and Lichtenstein<sup>11</sup> and Kernwein and Queen.<sup>12</sup>

## CASE REPORTS

**CASE 1.** A. M., a male, age fifteen, No. 492484, was admitted on July 13, 1942, complaining of pain in and about his left clavicle. Early in June, 1942, he had fallen on the right shoulder, but the left one hurt. He was admitted to a hospital on June 16, 1942. After x-ray study, a malignant tumor was suspected and an aspiration biopsy attempted. Insufficient tissue was obtained. He was discharged after a week. His pain and noticeable swelling about the clavicle persisted until his admission to the Mt. Sinai Hospital three weeks later or about six weeks from the date of onset.

Physical examination was negative except locally where there was a firm, tender, mass about the size of a hen's egg in or attached to the left clavicle in its outer third. There was

marked local tenderness. The skin was not adherent over it. A small supraclavicular nodule was felt on the left side but the boy had been aware of this for a long time.

Laboratory studies revealed the following: Temperature, pulse and respiration were normal. Sedimentation time was two hours seven minutes (Linzenmeier); blood hemoglobin was 91 per cent, white blood cells 8,900 per cu. mm. with a normal differential; eosinophiles were 1 per cent; urine and blood Wassermann tests were negative; blood calcium was 10.5 mg. per cent, phosphatase 17 King-Armstrong units per cent. Blood cholesterol was 290.

X-ray studies on July 14th (Fig. 1) showed an irregular expansion of the shaft of the lateral third of the clavicle. Bony trabeculae extended throughout a bony defect in the expanded area. The lesion was about 5 cm. long. At several points, the cortex had been completely eroded. There was a moderate amount of periosteal new bone formation extending mesially from the bony lesion along the shaft of the clavicle. Tentative diagnosis of a primary bone tumor was made with the most likely possibilities giant cell tumor, chondroma or chondrosarcoma. The chest and long bones were negative for any other lesion.

An open operation was decided upon with frozen section for diagnosis at the operating table. A small incision was made over the mass and a biopsy specimen removed. Frozen section without hematoxylin-eosin stain was inconclusive. In view of the possibility of malignancy, resection was decided upon. The outer half of the clavicle containing the lesion was removed *en masse*. (Fig. 2.) The "tumor" tissue had eroded through the cortex of the clavicle dorsally and, especially, inferiorly in the region of the coracoid process. Some of this tissue was attached to the soft tissue overlying the coracoid and was grossly removed thence. The supraclavicular nodule previously felt was also removed.

\* From the Orthopedic Service of the Mt. Sinai Hospital, New York, service of Dr. Robert K. Lippmann.

The wound healed by primary union and rapid functional recovery occurred. Eleven days postoperatively there was no deformity,

end of the left tibia. Marked tenderness, and a mild limp were present.

Laboratory studies revealed the following:



FIG. 1. Case 1. The destructive lesion of clavicle. Note expansion of the bone, erosion through cortex, pathologic infraction, periosteal new bone formation suggestive of malignant neoplasm.

no dysfunction of the left shoulder or arm, and no restriction of motion whatever. The pathologic report, dated July 23, 1942, by Dr. S. Otani, was solitary eosinophilic granuloma of the clavicle, and lymph node showing no significant changes except infiltration of eosinophilic leukocytes. (Fig. 3.)

After this report had been received, a course of x-ray therapy was given. This was in mild dosage, not as for malignant tumor. Excellent function has persisted without any disability or sign of recurrence to date. This is despite the fact that some bone regeneration occurred at the medial portion of the site of the resected clavicle. (Fig. 4.)

**CASE II.** R. D., a male, age two and one-half years, No. 504420, was in the hospital from April 21, 1943, to June 3, 1943, and again from June 11, 1943, to August 12, 1943. Four weeks before admission, this child began to awaken at night and cry with pain holding his left lower limb rigid. There was some limp when up and around, but no known fever or malaise. The pain and limp became progressively worse until three days before admission when his parents noted a local swelling on the left leg anteriorly which was very sensitive to touch. His temperature was then found to be 101° F. but this had subsided by the time of admission.

Physical examination was negative except for the local findings in the upper left leg. There was increased local heat, swelling, and infiltration of the soft tissues over the upper

Temperature, pulse and respiration were normal. Blood sedimentation rate was 48 minutes. Hemoglobin on admission was 72 per

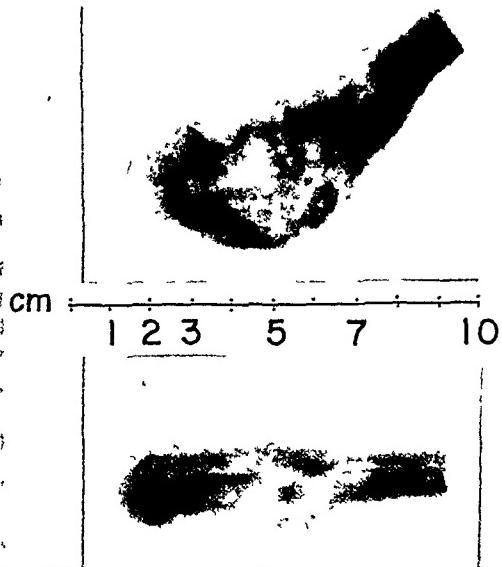


FIG. 2. Case II. X-ray of specimen removed at operation, outer half of clavicle including the lesion.

cent, and the white blood count was 8,000 with 3 per cent eosinophiles. A count two months later, on June 15th showed no significant change. Blood Wassermann and tuberculin patch tests were negative; urine examination was normal. Culture of the bone cavity at operation, both aerobic and anaerobic, was

negative, although later culture of the sinus which developed postoperatively showed *Staphylococcus aureus* A. A sternal bone marrow

medial but also in its anterolateral aspect. The destructive zone extended almost to the epiphyseal line in the diaphysis and was

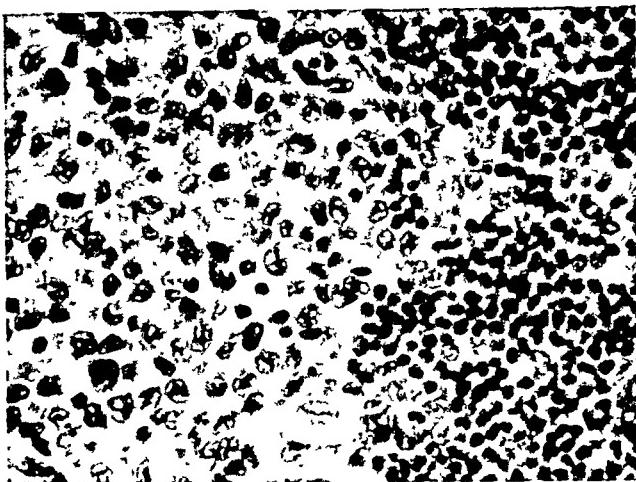


FIG. 3. Case 1. Note in the one field collections of large pale histiocytes, and in the other the darker clumps of eosinophils. These are bright red in the original slide stained with hematoxylin-eosin. X 525.



FIG. 4. Case 1, October 13, 1942, three months after operative resection, showing bone regeneration, but no evidence of the original lesion.

puncture on May 21st showed no increase in eosinophiles.

X-ray findings (Fig. 5) in the left leg showed a destructive lesion involving the proximal third of the shaft of the left tibia. The lesion had eroded the anterior cortex and invaded the medullary cavity as far as the endosteal zone of the posterior cortex. It had also extended laterally in either direction. It had produced a periosteal reaction mostly on its

eccentrically placed. The original tibia outline showed no expansion. Diagnostic ventures were (1) Ewing's tumor; (2) osteomyelitis.

Study of the long bones on April 24th, and the skull and ribs on April 30th showed no abnormality.

Operation was performed on April 24, 1943. Biopsy was done through a vertical skin incision over the lesion. A window was made in the cortex about 2.5 by 1.25 cm. A cavity

containing reddish gray soft material was entered. This was completely curetted and found to extend very close to the epiphyseal

Healing was complicated by formation of a sinus from the upper angle of the wound after a hematoma had collected. This became

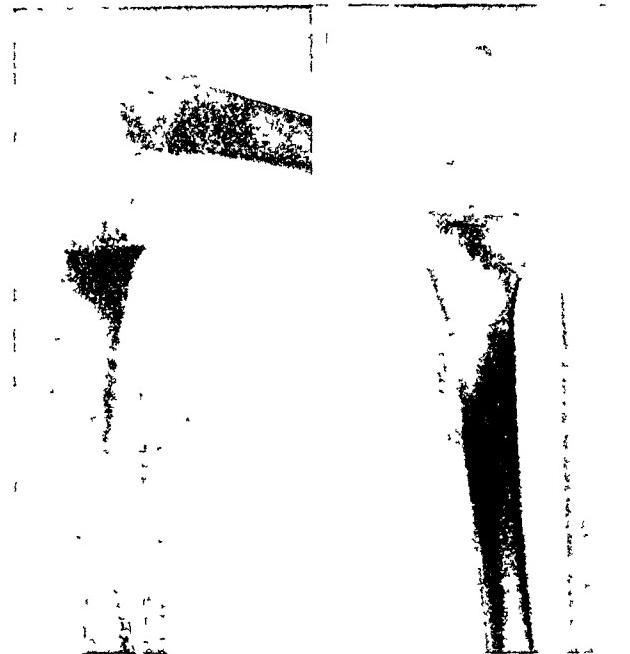


FIG. 5. Case II. Notice cystic, destructive lesion of upper end of tibia with periosteal new bone formation, without expansion of the cortex, suggesting osteomyelitis or Ewing's tumor.

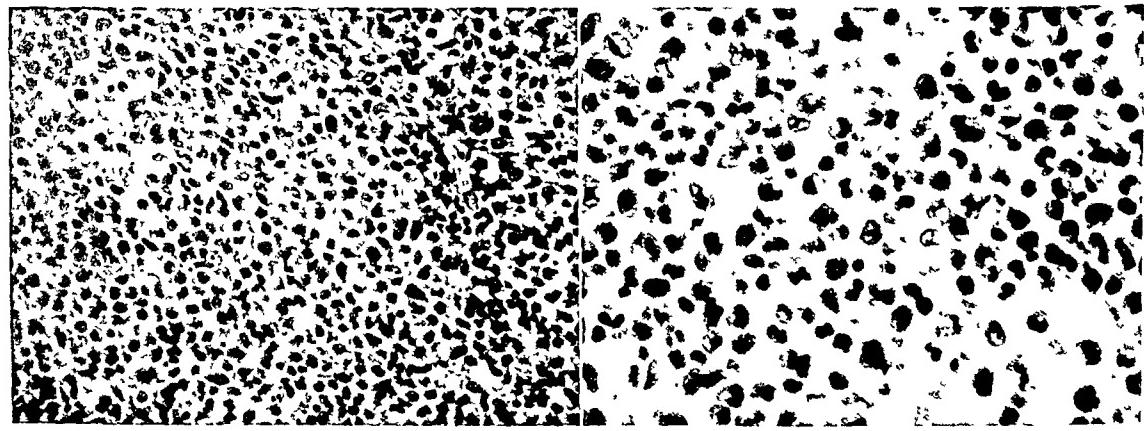


FIG. 6. Case II. A, showing mainly the histiocytes with scattering of eosinophilic leukocytes, and a few giant cells.  $\times 325$ . B, higher power showing more eosinophils, but many histiocytes and rare giant cells.  $\times 850$ .

line. Although the tissue resembled low grade infection, suggesting osteomyelitis, the wound was closed completely after introduction of sulfathiazole. Culture was taken of the bone cavity, anaerobic and aerobic. No cast was applied.

The pathologic report on the curettings, made by Dr. Otani on April 28th, was solitary eosinophilic granuloma. (Fig. 6A and B.)

frankly infected after a few days, culture showing *Staphylococcus aureus* A. He then developed intercurrent measles after exposure despite administration of pooled plasma and was discharged. He was readmitted June 11th for further treatment.

X-ray of the left leg at this time (Fig. 7) showed some bone regeneration but also an expansion of the bone at the original site of the

lesion which might have been due to periosteal new bone formation as reaction to operation. Roentgen therapy was then begun on July

regeneration of bone and reconstitution of the outline of the tibia with a general healing appearance of the lesion. He was sent to a



FIG. 7. Case II. Two months later, after curettage. Note expansion of metaphysis, probably by periosteal proliferation with continued erosion from within.

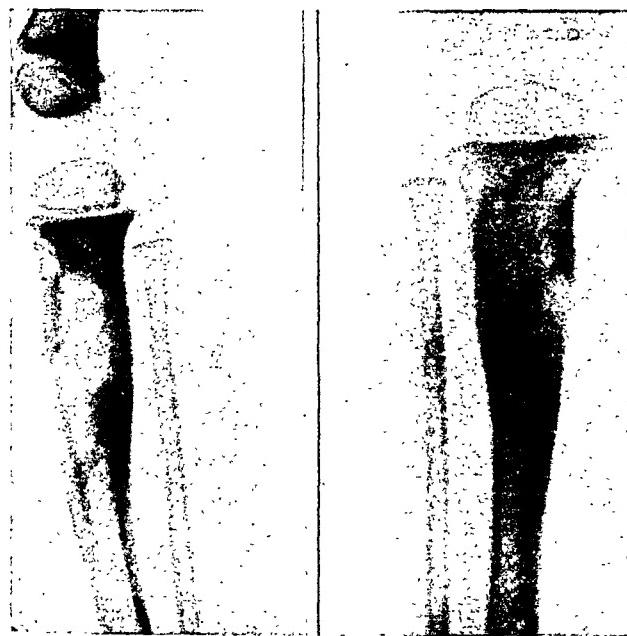


FIG. 8. Case II. After radiotherapy, three and a half months post-curettage. Note healing appearance of lesion with cortical regeneration.

1st, twelve treatments being given, of 75 r every three to four days.

The sinus promptly healed and bone regeneration ensued. By the time of discharge, x-ray examination (Fig. 8) showed considerable

convalescent home where he remained a month. Ever since he has been clinically well. The wound has remained well healed and the swelling has entirely disappeared. The mother states that at times he complains of some

vague pain in this leg. Tenderness and local reaction were entirely absent on his last clinical examination in April, 1944. Final x-ray study,

not always, of short duration. The lesion usually occurs in children and young adults. It can occur in older people as shown by a



FIG. 9 Case 11. After radiotherapy one year post-curettage Note excellent healing of bone.

(Fig. 9) shows practically complete healing of the lesion with bone regeneration.

#### DIAGNOSIS AND DIFFERENTIAL DIAGNOSIS

Eosinophilic granuloma is often a solitary lesion, although cases exhibiting simultaneous multiple lesions with the same pathologic picture have been reported. In these, the skull and ribs have chiefly been involved. The clinical picture is that of bone pain, generally, though

case in a man over fifty.<sup>16</sup> This might be expected in view of the destructive nature of the lesion. Our cases, and most of the ones in the literature involving long bones have been located near the ends of the bones, just as in many bone neoplasms and osteomyelitis. Trauma played a dubious part in one case, although reported in others in the literature. On examination, it is not possible clinically to determine whether the lesion is neoplastic or inflammatory as it partakes of the characteristics

of both in the various cases. Locally in our two cases, there was increased heat, soft tissue infiltration over the bone, local swelling and exquisite tenderness. Dysfunction of the limb or neighboring joints was due to the bone pain.

Laboratory findings are entirely unrevealing except for the x-ray examination of the local lesion. Temperature, pulse, sedimentation rate, blood calcium, phosphatase, cholesterol, white blood count, and differential as well as urinalysis are normal. No general eosinophilia has been found either in the blood count or in a single sternal bone marrow aspiration. X-ray examination of other long bones, chest, and skull in these cases has been negative for other lesions.

X-ray examination shows a primarily destructive lesion which has eroded the cortex of the bone, and even broken through the cortex in one or more places. At the same time, the bone may or may not be expanded at the site of the lesion. The cortex is preserved for the most part. Expansion of the shaft may be secondary to periosteal reaction as a result of fracture, operative trauma, or extension of the lesion through the cortex spontaneously. No bone sclerosis or formation occurs in the lesions themselves which appear rapidly progressive and destructive.

The diagnosis in each case was made only on pathologic study of excised material either at biopsy or after resection of the lesion. This emphasizes again the inadequacy of all clinical methods short of pathological examination in the diagnosis of doubtful or obscure bone lesions. Even pathological study may be inconclusive if not complete on adequate material, as is shown in our Case 1, in which a frozen section at the operating table showed a questionably "malignant" lesion while eosin stain later in the laboratory revealed the true nature of the condition. Diagnosis based on the x-ray films alone is misleading although we believe that future cases may be suspected before biopsy if the lesion is borne in mind.

In the case of solitary lesions, differential diagnosis must be made from primary bone tumors such as benign giant cell tumor, chondroma and chondrosarcoma, Ewing's tumor, osteolytic osteogenic sarcoma, bone cysts, and the various types of specific (luetic, tuberculous) and non-specific osteomyelitis. No detailed differential is required here as none of the findings is conclusive except through pathological study of excised material. Multiple lesions may be confused with generalized rare destructive bone diseases such as xanthomatosis, Hodgkin's disease, and metastases from neuroblastoma.

#### PATHOLOGY

The pathology has been amply described in detail by Otani, Jaffe, Farber, and others. The essential features consist of destruction of spongy and cortical bone by granulomatous tissue. This tissue is composed of two types of cells for the greater part. One type consists of large, pale staining mononuclear cells which are typical histiocytes. These may have mitotic figures which are never anaplastic. The other chief cells are the eosinophilic leukocytes. These may be so numerous as to color the microscopic field bright red with hematoxylin eosin stain, giving a characteristic appearance. Different fields may vary in the relative preponderance of these types. There is very little supporting stroma and little or no bone is left in the center of the lesion. Hemorrhage and necrosis occur occasionally. If pathological fracture has occurred, an ingrowth of fibrous tissue resembling callus has been noted as well as periosteal proliferation. Occasional giant cells of the osteoclastic type are present, but these are not characteristic. In neither of these cases, nor in any of the cases seen by Dr. Otani, have foam cells been found although sought for.

#### PATHOGENESIS

This is a relatively new clinicopathologic entity and as such has not been definitely classified. The etiology is, of course, un-

known. General opinion tends toward inflammatory rather than neoplastic origin, although no causative organism has been detected. The cases of multiple lesion have been likened and confused with xanthomatosis (Hand-Schuller Christian's syndrome), and non-lipoid reticulo-endotheliosis (Letterer-Siwe's disease). Indeed, the most recent publications<sup>10,11,20</sup> have emphasized this relationship. Green and Farber in reporting thirteen cases, have concluded that this lesion does not constitute a new disease, but represents one variant of a basic disease process, including Hand-Schuller Christian disease, certain forms of xanthomatosis and Letterer-Siwe disease. Gross and Jacox, in a report of three cases of multiple destructive lesions of bone, two of which are cases of xanthomatosis and one Letterer-Siwe disease, would seem to add further support to the theory that eosinophilic granuloma and xanthomatosis are variants of a basic disease process. Otani and Ehrlich, on the other hand, in discussing their report of four cases of solitary eosinophilic granuloma, regard this newly discovered lesion as a separate clinicopathologic entity, not to be confused with xanthomatosis.

The supposed similarity has been based chiefly upon the presence of many histiocytes in each of these lesions and the occasional appearance of many eosinophiles in all of them. Jaffe and others most recently have attempted to classify them as stages or phases of an identical underlying process presumably an obscure type of infection. The eosinophilic granuloma, although mild in nature, is supposedly the most acute phase. Letterer-Siwe's disease represents a disappearance of the eosinophils with emphasis on the histiocytes. Schuller-Christian disease would then be the most chronic phase with lipoid deposition in the histiocytes.

There are many difficulties inherent in such a classification. While in between and borderline cases of each of these conditions have been reported, we wish to emphasize that the clinical picture of our

cases of eosinophilic granuloma has in no way resembled the course of the other much more serious, indeed, fatal conditions. Regardless of the similarity of the histology of some of these cases, the clinical course is entirely distinct.

Xanthomatosis and non-lipoid reticulo-endothelioses are characterized by marked multiplicity of the lesions, involvement of the viscera, anemia, fever, and progressive downhill course in a variable period of time resulting fatally. Xanthomatosis, both general and local contain foam cells by the usual definition, and without these a definite diagnosis cannot be made. Eosinophilic granuloma on the other hand, is always benign, responds well to treatment, is not progressive, does not involve the viscera, and does not make the patient ill except for the local bone pain. No lipoid containing cells are found resembling foam cells.

We, therefore, believe that for the present, until further knowledge accumulates, these conditions should be regarded as separate clinicopathologic entities, rather than phases of the same general underlying disorder.

#### PROGNOSIS AND TREATMENT

Recognition of the lesion and its benign nature is very important in the management of the case. All the cases in the literature, with the exception of a few of the multiple ones which may have been cases of xanthomatosis, or non-lipoid reticulo-endotheliosis, recovered after curettage or resection either with or without subsequent radiotherapy. In a few of the multiple cases, some of the lesions disappeared spontaneously or after a small amount of radiotherapy. Our cases have been similarly favorable in outcome. Both patients are alive and well thus far with no sign of extension or recurrence.

All measures have been effective. Resection would seem satisfactory when the lesion is located in a bone which can be sacrificed with little or no functional impairment. This was satisfactory in one

of our cases even though some of the cellular tissue had to be left behind. The rôle of radiotherapy is more difficult to evaluate. In our CASE II, it is likely that it was important in controlling the lesion since the involved area appeared to expand and grow larger after curettage and sinus formation. It subsided gradually, with sclerosis and reconstitution of bone and healing of the sinus after twelve low-dose treatments such as are given for infectious and granulomatous lesions generally.

#### SUMMARY AND CONCLUSIONS

1. Two new cases of solitary eosinophilic granuloma of long bones are presented.

2. This is a well defined clinical and pathologic entity to be distinguished from similar multiple lesions which may represent variants of xanthomatosis or non-lipoid reticulo-endotheliosis.

3. Biopsy and careful pathologic study are necessary for the diagnosis. The pathologic characteristics of the lesion are given and its distinction from xanthomatosis.

4. Treatment consists of surgery, and/or radiotherapy in small doses as for inflammatory lesions. Surgery may be curettage or resection where practical without loss of function.

5. The patients are well at the present time. The lesions in these and the other

cases in the literature have all proven to be benign, without recurrence, at least thus far.

6. The solitary eosinophilic granuloma may turn out to be one of the more common of the destructive bone lesions in children and young adults and should be borne in mind in such cases.

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# HEMANGIOMA OF THE INTESTINE\*

GEORGE B. PACKARD, M.D.

Attending Surgeon, Colorado General and Denver Children's Hospitals  
DENVER, COLORADO

**H**EMANGIOMA of the intestinal tract is rare and is frequently overlooked in differential diagnosis. In most cases surgery at the proper time will effect a cure while the mortality in those untreated is extremely high. An additional and characteristic case seems worth reporting.

## CASE REPORT

F. J. D., Denver Children's Hospital No. 42-8703, a girl aged sixteen years, was admitted March 7, 1942, because of a marked anemia. The provisional diagnosis was anemia, etiology unknown.

Her family history was negative with no known bleeding tendency. In her past history, children's diseases were noted, she was subject to winter colds, the tonsils and adenoids had been removed at seven years without incident and she had had bronchopneumonia two years before.

She had always been pale as long as she can remember. More severe pallor came in attacks usually following some infection or gastrointestinal upset. These attacks were associated with nausea and vomiting, cramps, pain in the back and marked weakness. They occurred several times yearly. She was told that after these attacks her hemoglobin became as low as 40 per cent. After each attack she took liver and iron medicine and gradually improved. There was never noted any blood by bowel but at times the stools were quite black which appearance was ascribed to the iron. She has had a food craving, often eating paper, usually the unprinted part of magazines. Menstruation started a year before entrance and had been regular and scant.

Physical examination was essentially negative except for her skin which was pale and wax-like. The mucous membranes were also quite pale. Over the heart was heard a systolic murmur most pronounced at the base. The

abdomen was negative except that the spleen could be felt on deep inspiration.

On admission the hemoglobin was 22 per cent, red blood count 1,120,000, white blood count 6,400 with 79 per cent polymorphonuclears and 18 per cent lymphocytes; there were no abnormal cells. Reticulocytes made up 1.6 per cent of the reds. The stools were strongly positive for blood by the guaiac and benzidine test on a meat-free diet. The total protein was slightly low, 4.8. All other laboratory tests including an icteric index, red cell fragility, sternal puncture, gastric analysis and blood Wassermann were negative. A gastrointestinal x-ray series was normal, the jejunum and ileum being checked three times. Sigmoidoscopic examination was negative.

The child received frequent transfusions, a total of six preoperatively but the highest blood level was only 44 per cent with 2,880,000 red blood corpuscles. This was on March 31, 1942. However, on April 8, 1942, the child had rather severe abdominal pain, food craving appeared—she desired olives and paper—and the stools appeared quite dark but not tarry. Following transfusion a laparotomy was done on April 11, 1942.

A right rectus retracting incision revealed immediately a purplish tumor covering roughly 5 inches of the ileum over its whole circumference about 14 inches above the cecum. There were no adhesions. The blood supply did not seem to be excessive. The appearance was that of a mass of deep purple varicose veins. No other abnormality in the intestine was noted. There was a long normal appearing appendix and no Meckel's diverticulum. Six inches of the small intestine were resected, the ends closed and a lateral anastomosis performed with an inner layer of continuous fine catgut and an outer of interrupted silk. (Figs. 1 and 2.)

The postoperative course was entirely uneventful. The blood remained up without transfusion, the stools were negative for blood and the blood count at the time of discharge on

\* From the Departments of Surgery, University of Colorado Medical School and the Denver Children's Hospital.

April 26, 1942, was 78 per cent hemoglobin, 4,200,000 red corpuscles, 5,500 white corpuscles.

The specimen removed was reported by Dr. William C. Black as follows:

**Gross description:** Specimen consists of a segment of small intestine (ileum), 14 cm. in length, 5 cm. in width. There is a large roughly oval, purplish-red mass measuring 8 by 4 by 1.5 cm. lying in the wall of the intestine along its free margin. The mass nearly reaches the mesenteric border on each side. It is smoothly covered with peritoneum and consists of a great number of thin-walled blood vessels distended with liquid blood. When incised the tumor oozes blood freely. The lumen of the intestine is filled with liquid blood. The mucosa is directly underlaid by the tumor with resulting purplish discoloration and many uneven semi-polypoid elevations. Petechial hemorrhages are scattered through this portion of the mucosa. No large bleeding points are demonstrable. The intestinal wall, including the mucosa, above and below the tumor appears entirely normal.

**Microscopic Description:** The wall of the small intestine contains many endothelial-lined passages which branch and anastomose within the muscle layers and submucosa. Some of these contain blood while others are empty. The serosa forms the only outer covering for these vascular channels, and they are seen to reach into the mucosal stroma internally. There is no endothelial cell proliferation evident. A few of the vascular walls and channels are filled with amorphous calcium salt deposits.

**Diagnosis:** Cavernous hemangioma of small intestine. (Figs. 3, 4, 5, 6, 7 and 8.)

Not many cases of hemangioma of the intestine have been reported. Small angiomas on the body surface are common and may grow rapidly after birth but these tumors are much less common inside the body cavities. Geschickter and Keasbey<sup>1</sup> who reviewed 570 cases of hemangioma at the Johns Hopkins Hospital found only ten involving the internal viscera including the mesentery, kidney and gastrointestinal tract.

Cases appear in the surgical literature from time to time, most of which represent the single experience of the author. In 1922, Judd and Rankin<sup>2</sup> reported four cases from the Mayo Clinic, three heman-

giomas of the stomach and one of the duodenum. The outstanding symptom was hemorrhage. The different types of intestinal hemangioma were described by Brown<sup>3</sup> in 1924 after he had operated on a patient with acute obstruction due to an encircling hemangioma of the jejunum. He was able to find at that time nineteen other cases. He divided them into four groups ranging from capillary nevus up to encircling cavernous hemangioma. McClure and Ellis<sup>4</sup> collected twenty-four cases of which eighteen had symptoms and they reported one of their own. Exploratory laparotomy on their patient showed multiple hemangiomas of the liver and spleen as well as of the whole intestinal tract which prevented any removal. The patient died four months later from hemorrhage.

The most complete recent coverage of this subject is that of Kaijser.<sup>5</sup> He collected seventy-four cases from the literature and reported two of his own. One patient, a girl of nineteen, had an irremovable cavernous hemangioma of the stomach and esophagus; the other, a boy of eight with a hemoglobin of 20 per cent recovered after resection of the sigmoid for an infiltrating cavernous hemangioma. Kaijser has classified his seventy-four cases into four types with pathologic description and symptoms of each and is particularly interested in the phlebolith shadows frequently seen by x-ray as a diagnostic aid.

A typical long-standing case was reported by Pierose<sup>6</sup> in 1940. His patient, a woman of forty, had had spells of anemia associated with tarry stools for eleven years. At operation, three feet of small intestine were removed which showed diffuse telangiectatic cavernous hemangioma. She was reported well nine months later. An excellent review of the literature is added.

Christopher<sup>7</sup> found eleven cases reported since Kaijser's list which would make eighty-five up to 1942. His patient, a woman of twenty-six, had a long-standing anemia, 4 plus blood in the stool, a negative

x-ray. At operation a bright red coloration of both sides of the intestine down to the mesentery was found in the upper ileum.

communicating cavities. These are probably not true tumors but may be the result of some back pressure although they are



FIG. 1. Tumor delivered through abdominal incision before any clamps were applied.

Four inches of intestine were resected, microscopic diagnosis was congenital hemangioma of ileum with secondary ulceration and hemorrhage.

Hemangiomas of the intestine vary tremendously in type, distribution and course. The classification given by Kaijser which is stated to be essentially that of Oberndorfer seems an excellent one for

often given as examples of hemangioma of the intestinal tract. There are usually no clinical symptoms and very few have detectable hemorrhage in the canal. He lists twenty-seven cases.

2. *Cavernous hemangioma* is divided into those developing by diffuse permeation in the intestinal wall and into those growing more compactly, thus frequently becoming

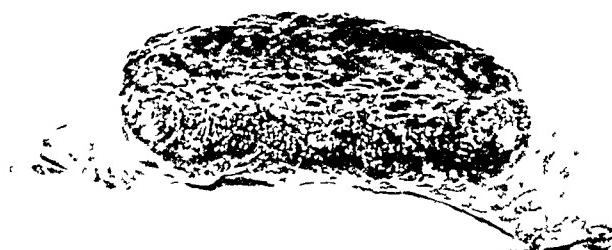


FIG. 2. Appearance of fresh specimen after removal; much of blood has run out.

practical purposes. He divides these angiomas into 4 groups as follows:

1. *Multiple phlebectasia* consists of dark bluish-red nodules ranging in size from pinhead to pea which are scattered over a limited portion of the intestine. These are usually in the submucosa though they may be subserous and are usually opposite the mesentery. Each one is connected with one of the smaller veins and is made up of

polypoid. These are the angiomas particularly prone to cause hemorrhage or obstruction. He lists thirty-two cases.

3. *Simple hemangioma* or capillary hemangioma is a network of dilated capillaries as compared to the large blood filled, thinly lined communicating cavities of the cavernous type. The simple type usually appears as a round submucous tumor, up to a plum in size, protruding into the canal

and covered by normal mucosa. Kaijser found seven cases.

4. *Angiomatosis* is his heading to cover

separation of blood-vessel tumors into classes is not of great value. It may simply be considered that hemangiomas are essen-

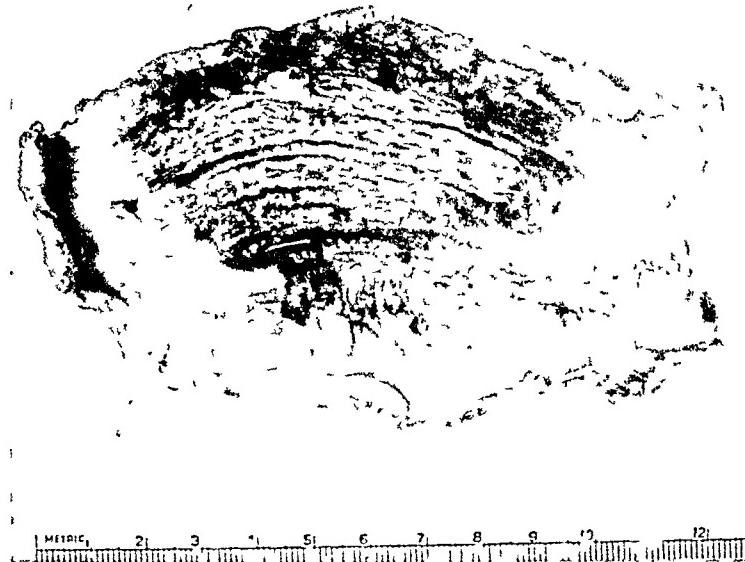


FIG. 3

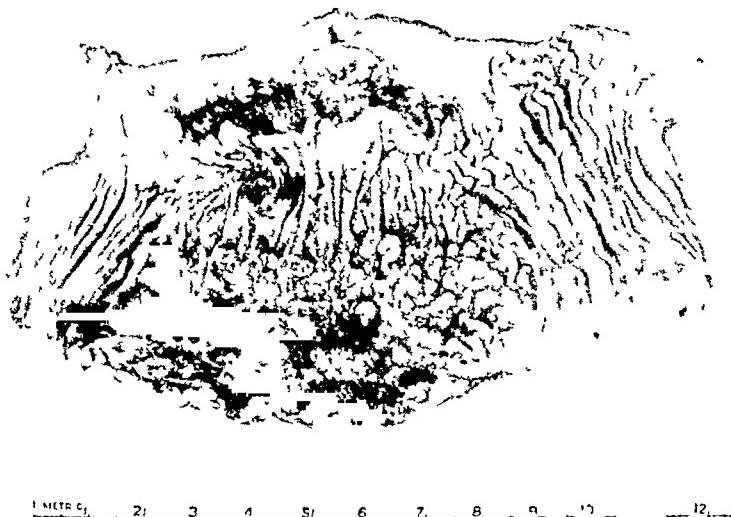


FIG. 4

FIG. 3. Cavernous hemangioma of small intestine; serosal surface.

FIG. 4. Cavernous hemangioma of small intestine; mucosal surface.

the occurrence of multiple angiomas varying in structure from the usual cavernous type to one rich in cells and stroma, some even suggesting angiosarcoma. Those in the intestine may be tiny nodules or plaques of considerable size but do not infiltrate and are usually on the surface away from the mesentery. Seven cases are reported.

From the surgical viewpoint, the definite

tially endothelial tumors composed of capillaries or dilated blood spaces or any gradation between the two. The tumors may be highly vascular or consist mostly of masses of endothelial elements. Any combination of the solid or open vessel type may be seen. They may be single or multiple. When sometimes these tumors seem to spread, the cause is usually a simple hypertrophy of the vascular elements with-

out neoplastic overgrowth. Malignant angiomas are far more rare though there are reports of metastases especially after trauma or repeated recurrence.

frequent is obstruction which may be due to polypoid encroachment on the intestinal lumen, to an encircling mass with added edema or to intussusception. Acute ob-

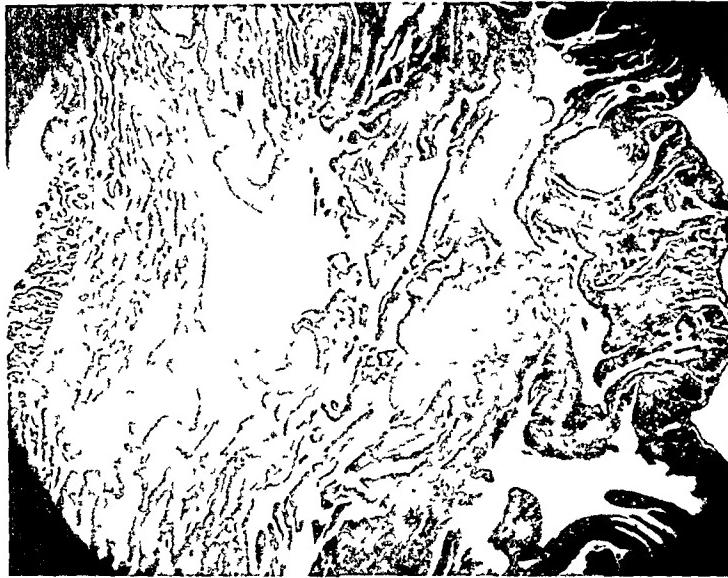


FIG. 5. Cavernous hemangioma of small intestine; microphotograph showing extensive involvement of entire wall.  $\times 18$ .



FIG. 6. Cavernous hemangioma of small intestine; microphotograph showing mucosal half.  $\times 60$ .



FIG. 7. Cavernous hemangioma of small intestine, microphotograph showing serosal half.  $\times 60$ .

While many angiomas give no sign of their presence, others may show most alarming symptoms requiring immediate interference. The characteristic symptom is hemorrhage often beginning in infancy. The bleeding may be undetected and yet be accompanied by a true anemia of long standing even associated with asthenia and cachexia. In other cases hemorrhage is severe enough to cause death. Less

struction seems more common than the chronic. A third symptom is due to acute inflammation of the tumor for which reason a diagnosis of appendicitis has been made in patients found to have instead angioma of the terminal ileum. In the report of McClure and Ellis,<sup>4</sup> for example, of twenty-four cases collected, there were symptoms in eighteen, hemorrhage in nine, acute

intestinal obstruction in four including one intussusception, chronic obstruction in three and acute inflammation in two.

Diagnosis before operating is rare. There are no diagnostic signs of certainty except in those tumors visible by endoscopy. Barium x-ray may in some reveal an intestinal tumor but does not suggest its nature. Kaijser<sup>5</sup> emphasizes repeatedly and noted in his own two cases the presence on the x-ray film of numerous rounded shadows of calcium density in the region later found to be the tumor site, these apparently being shadows of phleboliths within the angioma. This diagnostic sign he believes is usually confined to the cavernous type of hemangioma. In general, unexplained intestinal bleeding, in small or large amount, especially of long standing is the most typical sign and requires at least consideration of hemangioma as a diagnosis.

The danger of intestinal hemangioma depends largely on its type. Multiple phlebectasia seldom gives signs and is usually an incidental finding at autopsy or operation. In the other types there are many deaths from hemorrhage; all authors speak of the high mortality. In simple hemangioma an occasional death from hemorrhage has been reported; Kaijser<sup>5</sup> found one lethal hemorrhage in seven cases. The prognosis is much more grave in cavernous hemangioma. Some are too extensive for extirpation, in others acute hemorrhage or obstruction makes operation imperative at an unfavorable stage or death may occur without operation. Brown's<sup>3</sup> figures are not far from the average: twenty cases in which there were no symptoms in seven, while of the other thirteen, seven recovered and six died. In angiomatosis, in which multiple tumors involve too great an extent of bowel to permit resection, death from more or less constant hemorrhage is not too uncommon.

Nearly all of the cases successfully treated have been surgical resections. Cauterization or partial extirpation usually

has given only temporary relief. X-ray has given improvement in some cases though local radiation as by the use of



FIG. 8. Cavernous hemangioma of small intestine; microphotograph showing cavernous channels near mucosal surface.  $\times 120$ .

implanted radon seeds is seldom the practical procedure that it is on the body surfaces. The injection of a coagulating substance gave a brilliant result in Bancroft's<sup>8</sup> case but is probably not generally suitable. There may be more indication for injection than has been generally appreciated when one considers the success with this treatment in surface hemangiomas at the New York Memorial Hospital.<sup>9</sup> In those cases unsuitable for surgical removal, one may have to be content with some less complete attack or even with treatment of the anemia alone.

#### CONCLUSIONS

1. A patient who had suffered from severe secondary anemia for years was found to have unsuspected intestinal bleeding. Resection of a portion of the ileum which included a cavernous hemangioma apparently cured her anemia.

2. A few typical reports from the literature show similar characteristic signs.

3. Few hemangiomas are malignant, most are congenital and grow by blood vessel hypertrophy. They vary from tiny symptomless nevi to large cavernous

masses. They may consist mostly of blood spaces or of the solid endothelial elements or of any combination.

4. Symptoms include hemorrhage, obstruction and those of acute inflammation. Typical diagnostic signs are lacking.

5. Surgical cure is usually possible and is the treatment of choice at a favorable stage. Benefits from radiation and from injection have been reported.

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COLLECTIONS of pus deep in the cul-de-sac may be drained through the posterior vaginal wall. Patients must be selected carefully to avoid injury to the rectum or small intestine. Too vigorous or too extensive procedures may cause general peritonitis or an increase in the pelvic cellulitis.

From "Operations of General Surgery" by Thomas G. Orr (W. B. Saunders Company).

# BENIGN GIANT CELL TUMOR OF THE PATELLA

## CASE REPORT

F. J. ROEMER, M.D.

VANCOUVER, WASHINGTON

THERE are now twenty-one instances of benign giant cell tumor of the patella in the literature, including

believe that this type of tumor is the result of trauma to cartilage bones. The traumatic incident injures periosteal blood

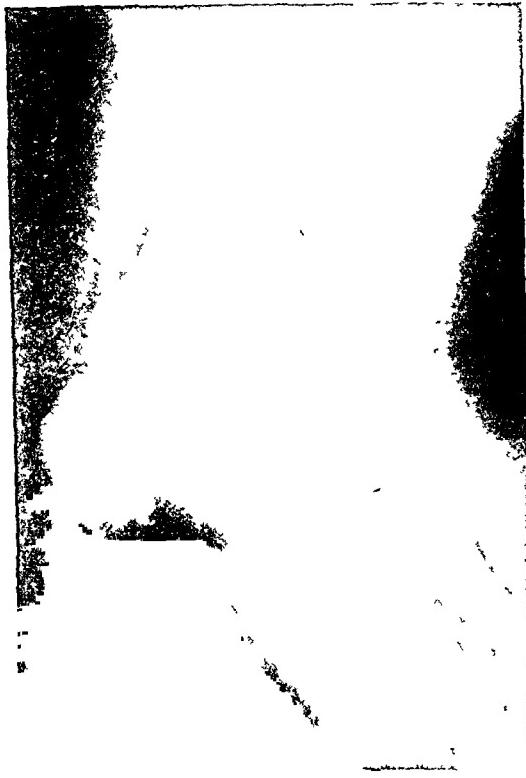


FIG. 1. Benign giant cell tumor at superior pole of patella.



FIG. 2. Postoperative radiograph showing hemipatelectomy.

the present case. None of the cases previously reported are described at such an early stage in pathological development. Despite study in this early stage, the present case does little to clarify the etiological factors concerned in the growth of benign giant cell tumors.

Embryologically, the patella goes through a well defined precartilaginous and cartilaginous phase in development. It has been the observation of Geschickter and Copeland that benign giant cell tumors occur exclusively in bones embryologically preformed from cartilage. These authors

vessels, and as a result there is impaired blood supply to an area of bone. Geschickter and Copeland consider the tumor as representing locally overstimulated osteoclastic activity which provides revascularization to this area of bone. They further point out that benign giant cell tumors form where the bone is spongy and relatively soft, such as in the proximal head of the tibia. Where there is mechanical resistance to growth of the tumor, such as in the heavy cortical bone in the shaft of the femur, the tumor remains quiescent as localized fibrocystic disease. The lining of the cysts in fibrocystic disease contains

many giant cells. Geschickter and Copeland's theory lends itself well to the findings in the patella where there is almost no

defect at the superior pole of the patella. (Fig. 1.) A preoperative diagnosis of benign giant cell tumor was made, and the tumor removed

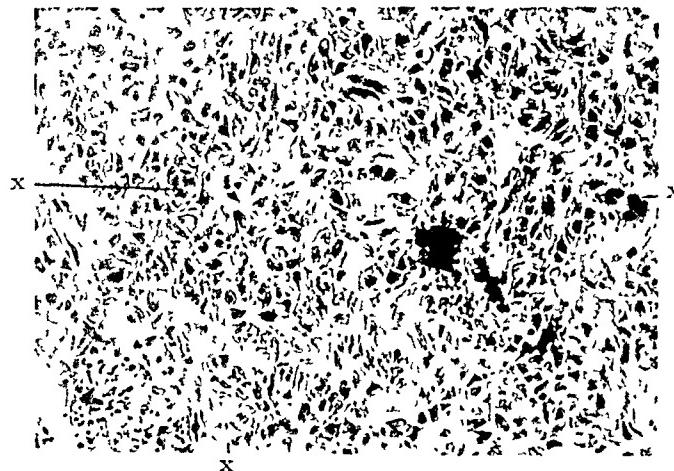


FIG. 3. Microphotograph of specimen, showing giant cells marked "x."

cortex and the bone is cancellous practically throughout.

Of the twenty cases of benign giant cell tumor already reported, at least three were cystic. History of trauma was recorded in the majority of cases, including the present one. This of course is of little significance, since the patella is so frequently injured in normal daily living. The alleged traumatic episodes occurred from several months to several years before the tumors were noticed, and often a year or so before the onset of the symptoms.

#### CASE REPORT

C. S., a white male shipyard worker, aged twenty-eight years, was admitted to the hospital on October 1, 1942. He complained of discomfort in the right knee cap. His past history was negative for bone or joint disease. On the industrial accident report the patient stated he had slipped on a steel plate and twisted his right knee a few days previously. After the question of workman's compensation arose, it was claimed that the initial trauma was a blow on the knee. On the other hand, the patient's aunt testified that he had complained of discomfort in the knee some months before the alleged accident.

X-rays were taken which revealed a cystic

under general anesthesia by Dr. Ernest Burgess. The quadriceps tendon was split over the patella in longitudinal fashion, and the upper one-half of the patella was shelled out and turned on edge. The cartilage underlying the tumor was necrotic and yellow, and the tumor appeared to be almost at the stage of proliferation into the joint. An amputation saw was then used to divide the patella transversely in its mid-portion, and the tumor-bearing portion was excised. The quadriceps tendon was then resutured carefully with No. 1 chromic catgut, approximating it to the free raw margin at the site of patellar amputation. A long leg plaster cast was applied from the upper thigh to just above the ankle, with the knee in complete extension.

The postoperative course was uneventful, and the patient was able to return to work one month later. The cast was left on for three and one-half weeks. Slight effusion and quadriceps atrophy were noted five weeks postoperatively. Several months later the patient's recovery was complete. He was accepted by the Navy and is now in service.

Report of pathological examination by Dr. Thomas D. Robertson is as follows:

"Examination of the sections prepared by decalcification, and as seen under the microtessar lens shows bone trabeculae separated by fatty marrow. Towards the cortex the trabeculae become thicker and more compact. It is seen that down in the trabeculated portion

there is a well defined cellular zone which, however, is not surrounded by a capsule, with the cellular tissue extending out in the neighboring

nucleus, while the other cell is a giant cell with many small nuclei like those in the other cells. These giant cells are scattered throughout. Ex-

TABLE I

Author	Year	Age	Sex	Diagnosis	Methods of Diagnosis	Recurrence	Etiology	Operation	Metastases
Wilks, Samuel	1842	24	F	Myeloid disease	Microscopic		Trauma	Amputation	o
Cooper, Sir Astley	1895	.		Cystic endosteal myeloid sarcoma	Microscopic				o‡
Jones, R	1895	20	F	Endosteal sarcoma	Microscopic		Trauma	Amputation	o§
Horai	1896	39	F	Myeloid sarcoma	Microscopic		Trauma	Amputation	o
Kudak, F	1907	25	M	Central giant cell sarcoma	Microscopic		Trauma	Excision	o
Moranek, A	1907	30	M	Giant cell sarcoma	Microscopic		Trauma	Excision, plastic	o
Wanach, R	1910	37	F	Primary sarcoma	Microscopic		Trauma	Excision, plastic	o
Baldwin	1925	19	M	Giant cell tumor	Microscopic		Trauma	Excision	o
Cole, W. H	1925	32	F	Osteitis fibrosa with giant cells	Microscopic	Once	Trauma	Curettetement with phenol	o*
Faltin, R	1925	27	F	Giant cell tumor	Microscopic		None	Curettetement	o
Abadie, J	1928	45	F	Giant cell tumor	Microscopic			Excision	o
Abadie, J	1928	31	F	Giant cell tumor	Microscopic		Trauma	Curettetement, plastic	o
Giordano, G	1928	20	F	Giant cell tumor	Microscopic		Trauma	Excision, plastic	o
King, M. J. and Towne, G. S	1929	19	M	Primary giant cell tumor	Microscopic	Once	Trauma	Curettetement	o*
Indan, A	1930	35	F	Giant cell tumor	Microscopic		Trauma	Excision, plastic	o
Kraft, E	1931	32	F	Giant cell tumor	Microscopic		?	Curettetement	o
Geschickter and Copeland	1931	31	F	Spindle cell variant	Microscopic		Trauma	Curettetement	o
Linde, S. A	1932	37	M	Giant cell tumor	Microscopic		Trauma	Excision, plastic	o†
Dillehunt and Chirnard	1938	34	F	Giant cell tumor	Microscopic		None	Excision, plastic	o
Levine, M. A	1943	31	M	Cystic benign giant cell tumor	Microscopic		Trauma	Excision, plastic	o
Roemer, F. J.	1943	20	M	Benign giant cell tumor	Microscopic		?	Excision, plastic	o

\* Note that in both cases of recurrence curette technic had been used.

† No. 1162—Registry of bone sarcoma of the American College of Surgeons.

‡ Hunterian Collection—Royal College of Surgeons No. 1637.

§ Hunterian Collection—Royal College of Surgeons No. 1637A. This case was published by D'Arcy Power. In review of his paper in the British Medical Journal, 1895, p. 419, mention is made of a sarcoma of the patella reported by Mr. Pepper.

trabeculae, but the area is somewhat spherical, quite well defined, with no trabeculae coursing through it.

"With the low power lens one can see an admixture of two main types of cells. One type is either polyhedral stellate or spindle shaped with single rather pale staining finely granular

amined under the high power lens there are no mitotic figures and the cells do not have the large nucleoli of a malignant cell. There is nothing to suggest malignancy. Blood pigment is not noted.

"Pathological Diagnosis: Benign giant cell tumor of the patella."

Since out of 250 benign giant cell tumors reported by Geschickter and Copeland, there were thirty-one recurrences and three metastases, it would seem advisable to resect the entire lesion when working in areas where this can be done and still preserve function. In dealing with patellar tumors this plan is certainly preferable to the common practice of curetting out the tumor and cauterizing the tumor bed. In reviewing the series of patellar giant cell tumors it is seen that the only two cases of recurrence appeared after the curettment technic was carried out at the primary operation. Geschickter and Copeland, and William B. Coley point out that it is not always possible to differentiate malignant tumors from benign giant cell tumors even by means of complete x-ray and careful microscopic study. An excellent functioning knee is obtained by hemipatellec-tomy, and a good knee is obtainable with total excision of the patella. These two would seem to be the procedure of choice. The entire lesion and a margin of healthy tissue around it should be removed.

Changing terminology has led to some confusion. All the following terms have been used in the past to describe what we commonly know as benign giant cell tumor: Benign giant cell sarcoma, medullary giant cell sarcoma, primary sarcoma, giant cell sarcoma, giant cell tumor, primary giant cell tumor, endosteal myeloid sarcoma, myeloid disease, myeloid tumor, myeloid sarcoma, and osteoclastoma.

It is obvious that osteitis fibrosa cystica in some stages is indistinguishable from benign giant cell tumors containing cysts, thus allowing some elasticity in diagnosis. Lesions reported by William B. Coley, M. A. Levine, and the case of Sir

Astley Copper mentioned in a paper by D'Arcy Power were cystic. Geschickter and Copeland report a spindle cell variant of benign giant cell tumor in a thirty-one-year old white woman which was treated by curettage. The patient was well when last seen six years later.

#### CONCLUSIONS

1. A very early case of benign giant cell tumor of the patella is reported.
2. The average age of patients is 29.4 years.
3. The lesion predominates in females with a ratio of 13 to 7.
4. Optimum treatment requires resection of the patella, removing a margin of healthy tissue and reconstruction of the quadriceps mechanism.
5. The occurrence of benign giant cell tumors of the patella is compatible with the theory that these tumors occur exclusively in cancellous bone which embryologically was preformed of cartilage.

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# CRUSHING OF PHRENIC NERVE AND MULTIPLE COSTOTOMIES

## AIDS IN THE REPAIR OF A LARGE IRREDUCIBLE INCISIONAL HERNIA

CLARENCE E. REES, M.D.

Chief Surgeon, Rees-Stealy Clinic

SAN DIEGO, CALIFORNIA

THE following case report describes two auxiliary procedures used in the repair of a large incisional hernia, namely, crushing of the phrenic nerve and multiple costotomies.

### CASE REPORT

The patient was a man, fifty-five years of age. He stated that the hernia had been present since 1931 and that it followed a cholecystectomy with postoperative pulmonary complications. Severe coughing had resulted in a complete separation of all of the deep structures in the line of incision. Six months later an attempt was made to repair the hernia but again pulmonary complications with coughing ensued and the attempt was not successful. Two years after that another repair was attempted, this time with the aid of fascial transplants from the thigh, but this, too, had failed.

The hernia was an extremely large one, easily the size of a football, and was only partially held in place by a specially made belt. The hernial ring extended through the upper one-half of the right rectus muscle; it was about 5 inches long and  $2\frac{1}{2}$  inches wide; and its margins were rigid. Complete reduction was not possible. About two-thirds of the contents could be replaced in the abdomen but one-third remained in the hernial sac. Even the loss of ten pounds in weight by means of a reduction diet, did not aid in replacement. It was apparent that the usual methods of repair would not be successful and that some additional procedure or procedures would be necessary.

As the first step, the right phrenic nerve was crushed, under local anesthesia, in order to produce a rise in the right diaphragm and thereby increase the size of the abdominal cavity. The desired result was obtained. Immediately following this procedure it was possible to replace the hernial contents completely within the abdominal cavity. Fluor-

oscopy revealed an elevation of the right diaphragm of about two and one-half inches.

Two weeks later, under general anesthesia, repair of the hernia was undertaken. An incision was made over the central portion of the hernia, dissection was carried down to the hernial hiatus, and the peritoneal portion of the sac was removed. The sac consisted only of skin and peritoneum both of which were very thin. The posterior rectus sheath was then dissected free from the anterior sheath completely around the margins of the opening. These were very firm structures. The atrophic fibers of the rectus muscle lay between them. It was then found that only with considerable tension was it possible to approximate the fascial margins; in fact, the tension was so great that it appeared useless to attempt closure under the circumstances.

It had been noted that as a result of his weight loss, the costal arch flared on each side and the upper abdomen was scaphoid in shape. This fact suggested that the mobilization of the costal arch on the right might relieve the tension sufficiently to make it possible to approximate the fascial margins easily, and thus greatly aid in closing the hernial opening. Accordingly, the dissection was carried up over the lateral chest wall to the axillary line exposing the tenth to seventh ribs and the tenth, ninth, eighth, and seventh ribs were sectioned subperitoneally in an arc running medially upward. The costal cartilages of these ribs were severed at their attachments to the sternum. The lower part of the right costal arch was immediately mobilized by this procedure, with the desired results. It was then possible not only to approximate the structures forming the hernial margins but also to overlap them by about one and one-half inches.

The lateral side of the posterior rectus sheath was then sutured under the medial side of the posterior sheath with an overlapping of one

and one-half inches; the free margins of the medial posterior sheath were sutured to the top of the lateral posterior sheath; the lateral side of the anterior sheath was sutured over the anterior surface of the posterior sheath; and the remaining leaf of the anterior sheath was sutured over the anterior surface of the opposite anterior sheath. Continuous chromic catgut sutures were used in the first three closures and interrupted silk sutures in the fourth. A very firm closure was obtained. The skin was closed with clips and a drain was inserted through a stab wound.

The postoperative course was uneventful. No pulmonary complications developed, and, contrary to our expectations, the pain as a result of the rib fractures was not excessive.

An opportunity to observe the results of closure presented itself five weeks later when it was necessary to open the incision and remove the silk sutures because of superficial infection. The abdominal wall was firm throughout and the deep structures apparently were well healed.

#### SUMMARY

The repair of a large incisional hernia, which could not be accomplished by the usual methods, was made possible by two additional procedures, (1) crushing of the phrenic nerve, and (2) multiple costotomies.

1. Crushing of the phrenic nerve produced an elevation of the diaphragm which provided more room in the abdominal cavity and permitted reduction of the hernia. This procedure may have an additional advantage in selected cases because it removes the muscular action of the diaphragm on the affected side in the event of such postoperative complications as vomiting, coughing, etc.

2. Multiple costotomies on the affected side were a definite factor in the successful repair of the hernia since they resulted in mobilization of the costal arch so that the hernial margins could be overlapped without tension.



# New Instruments

## A SIMPLE SKIN GRAFT KNIFE FOR GENERAL USE\*

LT. COMDR. G. V. WEBSTER, M.C.

UNITED STATES NAVAL RESERVE

DURING recent years, a multitude of devices, machines and other contraptions for cutting skin grafts have been introduced by surgeons and surgical supply houses. Nearly all of them require the application of a cement or other substance to the skin and in many cases, this makes the graft difficult to handle, particularly when only small grafts are needed.

There have been two reasons for the introduction of such a collection of devices: (1) The value of early skin grafting of burns and other surface defects has been irrefutably established, and so there has been a great demand for grafts, especially of the split-thickness type described by Blair and Brown.<sup>1</sup> (2) It is wrongly assumed that the average surgeon cannot cut a thick-split graft by a free-hand technic. Some utopian device has been sought whereby the needed graft can be obtained without hacking-up and morcellating donor sites to the extent that sometimes a donor defect is created which is worse than the recipient site.

Most surgeons have tried to cut a free-hand graft from time to time and, having met with indifferent success, have turned to expensive and complicated devices or have referred even simple cases to the plastic and reconstruction surgeon. While the latter is admittedly most desirable, there are a great many cases, particularly with the current shortage of skilled phy-

sicians and surgeons, wherein crippling deformity could be prevented by early grafting by the general surgeon, provided he is willing to spend the time and pains necessary to prepare the recipient site and give proper after-care.

### AUTHOR'S INSTRUMENT

The one instrument with which the general surgeon has had the most success in cutting grafts is an old-fashioned straight razor. If the razor is *sharp*, nearly anyone can cut a graft by the free-hand technic with fair success. There are two difficulties, however, which are frequently encountered. The razor is clumsy to hold and secondly, it is rarely sharp enough.

To obviate these difficulties a skin-graft knife has been constructed which consists of an inexpensive and rigid handle and removable "straight razor" single-edge blades\* which can be purchased in packages of five for a few cents at the corner drug store. (Fig. 1.) Such a knife is a remarkably successful instrument. (Fig. 3.) No suction box nor other apparatus is necessary.

### METHOD OF CUTTING GRAFTS

The methods of preparing the recipient area are well publicized and are beyond the scope of this paper. It does seem

\*Wекк & Co., Brooklyn, N. Y. 'Sextoblade'.

\* From the Division of Plastic and Reconstruction Surgery, Department of Surgery, National Naval Medical Center, Bethesda, Md. The opinions or assertions contained herein are the private ones of the writer and are not to be construed as official or as reflecting the views of the Navy Department or the Naval Service at large.

appropriate, however, to mention in some detail the exact method of cutting a graft by the free-hand technic.

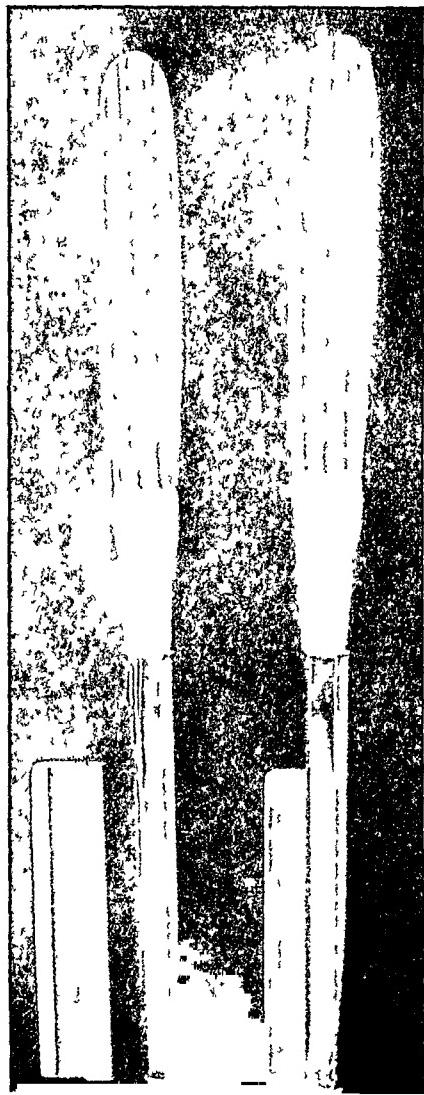


FIG. 1. The author's skin-graft knife.  
A, assembled; B, with removable  
blade (Weck & Co. "sextoblade")  
detached.

A donor site is selected (usually the thigh for men and the buttock for women) and prepared by cleansing with green soap, removing the soap with ether and painting with tincture of iodine ( $3\frac{1}{2}$  per cent). The skin is then covered very lightly with a thin film of petrolatum and the excess scraped off with the edge of a sterile tongue depressor.

The operator stands so as to be able to cut a graft from right to left, if he is right-handed or left to right if he is left-handed. His assistant stands on the same side as the operator and either above or below him depending upon whether the graft is being cut up or down the leg. It is the duty of the assistant to give countertraction by means of a flat surface such as a tongue depressor wound with gauze so that it will not slip. (Figs. 2 and 3.)

The operator holds in his left hand a straight edge of some type, the most readily available of which is a sterile tongue depressor. (Figs. 2 and 3.) The assistant has in his free hand a pair of forceps with which to steady the graft as it comes over the back of the knife. The nurse holds a sponge wet with normal saline and drips a few drops on the blade should they be required to moisten and lubricate the knife.

With a good light on the field, the operator begins a longitudinal "to and fro" motion with the blade, steadying the skin with the tongue depressor in his left hand. The knife, which in the case of the author's instrument will be absolutely fresh and sharp, will sink into the skin to the required depth. Then, seemingly without any conscious effort of pushing the knife forward, the blade travels into the skin and parallel to the skin surface. Emphasis should be placed on avoiding any forward push of the knife. With the tongue depressor in the left hand keeping just ahead of the blade, the graft is cut, keeping the knife at that distance from the surface where the blade looks slightly blue beneath the severed graft.

In this way, with close attention to detail, grafts of uniform thickness and width can be cut to almost any desired length. (Fig. 3.) Their width, however, is limited to about two and one-half inches. If wider grafts are desired, the standard Blair knife, the Ferris Smith modification of the Blair knife, or the dermatome should be used. Even small grafts laid side-to-side can cover a huge surface area and

the resulting growing skin will serve all functions for which thick-split grafts are intended.

hand technic because there is provided an extremely sharp blade and a convenient handle. Only a little practice is necessary

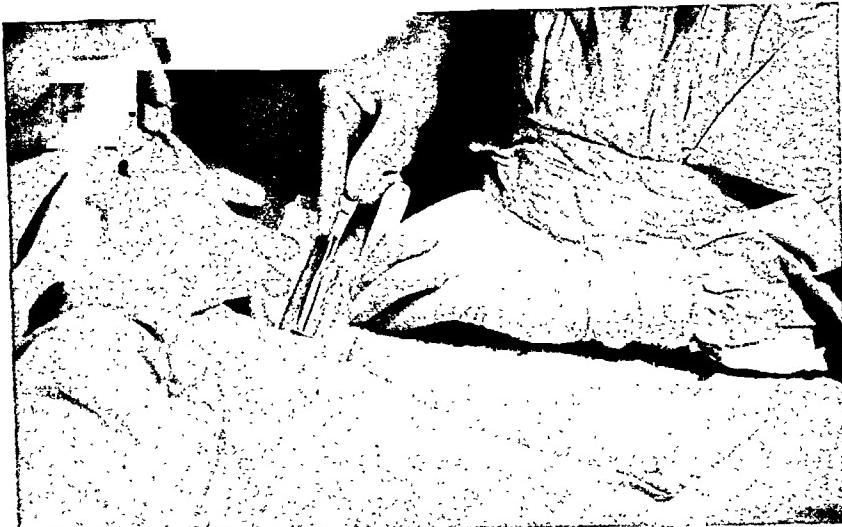


FIG. 2. The position of operator and assistant as graft-cutting operation is begun.



FIG. 3. Graft being removed. Note uniform thickness, even edges and simplicity with which graft is cut. The graft is retracted as it lies on the bed from which it was removed, but yields a full two-inch width with ease.

#### SUMMARY

A simple, inexpensive skin graft knife is presented which utilizes two and one-fourth inch removable packaged razor blades. The knife can be used easily by even inexperienced operators to cut Thiersch or thick-split grafts by the free

to acquire facility which will give the general surgeon a ready source of skin grafts for a multitude of purposes.

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# A RETRACTOR

DESIGNED TO FACILITATE EXPOSURE IN OPERATIONS ON THE SPINAL COLUMN  
AND OTHER DEEP STRUCTURES

HENRY W. MEYERDING, M.D.

Section on Orthopedic Surgery, Mayo Clinic

ROCHESTER, MINNESOTA

**A** RETRCTOR which will grasp and hold tissues deep in wounds during operations, especially during those on the spinal column, has been diffi-

become a standard instrument employed during fusion operations on the spinal column, operations for intervertebral disks and in other deep surgical wounds.

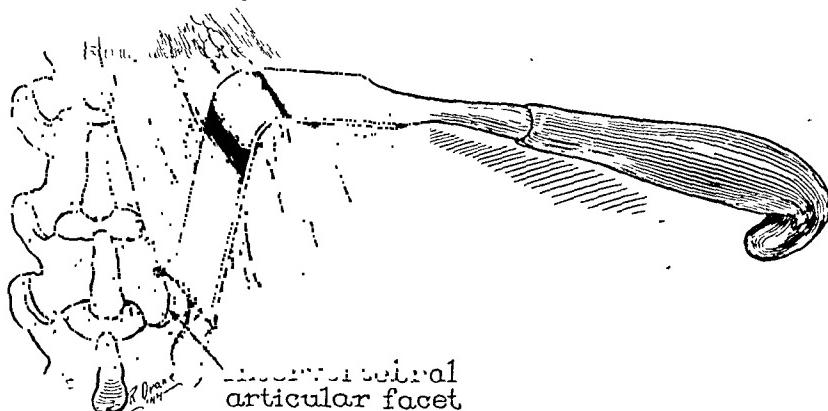


FIG. 1. Retractor in position and exposing the intervertebral articular facet.

cult to obtain. Many of the retractors available have smooth or rounded edges, which slip over the deep structures which are to be retracted. Furthermore, many of the handles of such instruments are poorly shaped and of insufficient size which makes it difficult for the assisting surgeon to maintain them in correct position without discomfort or shifting hands from time to time. With movement of the retractor the soft tissues slip away from it and thus obstruct the surgeon's view. The surgeon and assistant are needlessly annoyed and operations are prolonged, since even the most capable assistant finds it impossible to maintain adequate exposure with an improper retractor.

After trying many types of instruments, I designed the retractor herein described, which in the hands of my associates as well as in mine has proved to be far more satisfactory than any instrument that has been employed heretofore. It has

This retractor is  $8\frac{3}{8}$  inches (21.3 cm.) in length with a blade 3 inches (7.6 cm.) long, 1 inch (2.5 cm.) wide and  $\frac{1}{16}$  inch (0.16 cm.) in thickness. It is bent into an acute angle of 72 degrees; the tip is notched with teeth that are angulated about 60 degrees and fairly sharp, so that once they are inserted into fibrous tissue the retractor remains in position. It is sufficiently strong so that considerable pull can be placed on it without bending it. The end of the handle is  $4\frac{1}{2}$  inches (11.4 cm.) in length and oval on cross section; it becomes increasingly thicker as it reaches the end thus permitting a firm grasp without discomfort. The extreme end forms a hook which rests against the little finger and prevents slipping. Such a retractor may be held for prolonged periods without discomfort; and as it gently pulls and forces outward, it maintains its hold on the fibrous structures.

I employ several of these retractors of varying depth and width. (Fig. 1.)

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